Comprehensive Chemotherapy and Biological Therapies Course

UPMC Hillman Cancer Center

UPMC
LIFE CHANGING MEDICINE

Table of Contents

Alkylating Agents

History of Alkylating Agents

- World War I
  - Sulfur mustard gas used as military weapons
  - Vesicant properties caused skin irritation, blindness, and pulmonary damage
- World War II
  - Sulfur mustard spill in Bari Harbor, Italy
  - Exposed sailors suffered bone marrow depression and lymph node depletion
- Observations led to further study of less toxic nitrogen mustards for cancer treatment

Mechanisms of Action

- Cell cycle nonspecific
  - Work on dividing and resting cells
  - Effective in slow growing tumors
  - Effective in large tumors that have relatively few actively dividing cells
- Mechanism of action number one
  - Binds to DNA and forms cross bridges between DNA bases
  - DNA cannot unwind for DNA replication
- Mechanism of action number two
  - Cause mispairing of nucleotides (mutations) during DNA replication or DNA repair
- Mechanism of action number three
  - Attach alkyl groups to DNA bases which results in DNA being fragmented by repair enzymes in attempt to repair and replace the alkylated bases

Toxicities Common to All Alkylating Agents

- Nausea/vomiting
  - Emetogenicity varies
- Myelosuppression
- Infertility
  - Consider fertility preservation strategies
- Hypersensitivity reactions: Rare
- Alopecia: Reversible
- Secondary malignancies: Mostly MDS/AML
- Tumor lysis syndrome, in certain clinical scenarios
- Pregnancy category D, evidence of human risk

Common Contraindications to Alkylating Agents

- Avoid use in patients with active infections
- Avoid live vaccinations
- Prior known hypersensitivity

Mustargen, Valchlor (mechlorethamine)

- Prototype nitrogen mustard
- Highly unstable molecule
- Routes of administration
    - Topical
        - Mechlorethamine 0.016% gel (Valchlor®)
    - IV administration
        - Unstable: Use within one hour of preparation
        - Inject over 1-3 minutes into running IV solution
    - Intracavitary administration
        - Pleural effusions, peritoneal ascites, and pericardial effusions

Indications

- Hodgkin lymphoma
- Mycosis fungoides

Adverse Effects

- Emetogenicity: IV
    - High
- Atopic dermatitis: 50-67%
    - Topical administration
- Thrombophlebitis
- Extravasation
    - Sodium thiosulfate
    - Ice compresses

Cyclophosphamide

- Requires hepatic metabolism to active form
- Further metabolized to acrolein and phosphoramide mustard
- Oral bioavailability approximately 75-100%
    - Supplied in capsules (25 mg and 50 mg) as well as powder for IV administration
- Half-life 4-16 hours
- Urinary excretion

Common Indications

- Breast cancer
- Non-Hodgkin's lymphoma
- Multiple myeloma
- Acute lymphoblastic leukemia
- Chronic lymphocytic leukemia
- Sarcomas
- Stem cell transplantation
    - Conditioning regimens
    - Graft versus host disease prophylaxis
- Autoimmune disorders
    - Lupus nephritis

Adverse Effects

- Emetogenicity
  - >1500 mg/m^2 IV or combined with anthracycline
    - High
  - ≤ 1500 mg/m^2 IV
    - Moderate
- Hemorrhagic cystitis
  - Higher incidence with chronic use and high doses
  - For high dose cyclophosphamide
    - Monitor urine dipsticks for blood
    - Administer mesna and IV fluids
    - Encourage frequent voiding
    - Administer in the morning if possible
- Cardiomyopathy: High dose
- SIADH: Rare
- Pulmonary fibrosis

Ifex (ifosfamide)

- Isomer of cyclophosphamide
- Prodrug: Activated in liver to 4-hydroxyifosforamide
- Further metabolized
  - Toxic metabolites
    - Acrolein: Hemorrhagic cystitis
    - Chloracetaldehyde: Neurotoxicity
  - Active metabolite
    - Phosphoramide mustard
- Oral bioavailability nearly100%
  - Never given PO: Highly toxic
- Half-life 7-15 hours
- Urinary excretion

Common Indications

- Soft tissue sarcoma
- Lymphoma
- Testicular cancer

A 32-year-old patient is receiving doxorubicin/Ifosfamide (AI) for soft tissue sarcoma. He is found to be obtunded, lying in soiled clothing and linens.
Which treatment might be ordered in an effort to accelerate the recovery from Ifosfamide induced encephalopathy?

A. Vitamin B12
B. Vitamin B12
C. Leucovorin
D. Methylene blue

Adverse Effects

- Emetogenicity
  - Dose ≥ 2 gm/m^2: High
  - Dose < 2 gm/m^2: Moderate
- Hemorrhagic cystitis
  - Mesna mandatory
  - Monitor urine dipsticks/urinalysis
  - Consider holding or reducing Ifosfamide dose if > 50 RBC/hpf
- CNS toxicity
  - Encephalopathy
- Renal failure
  - Acute and chronic
- SIADH
  - Rare
- Hepatotoxicity

Ifosfamide Induced Encephalopathy

- Incidence: 10-15%
- Encephalopathy symptom onset 2-48 hours after infusion
- Pathogenesis
  - Accumulation of neurotoxic metabolite, chloracetaldehyde
- Symptoms
  - Disorientation
  - Confusion
  - Hallucinations
  - Agitation
  - Coma

Risk Factors

- Renal dysfunction
  - Pelvic mass
  - Low albumin
  - Previous nephrectomy
  - Previous cisplatin administration

Treatment

- Discontinue ifosfamide
- Consider methylene blue 50 mg IV every 4-8 hours until resolution
- Supportive care
- Spontaneous resolution usually occurs in 24-72 hours

Mesna

- Urinary tract protectant
- Used to decrease the incidence of hemorrhagic cystitis from Ifosfamide and high dose cyclophosphamide
- IV formulation
- 400 mg scored tablets

Dosing

- Standard dose: < 2.5 gm/m^2/day short infusion ifosfamide
    - Mesna IV total daily dose equals 60% of ifosfamide dose split evenly into three doses: 15 min before, 4 hours after, and 8 hours after Ifosfamide
- To substitute oral Mesna tablets for the 2nd and/or 3rd IV dose, double the dose and give two hours before the scheduled IV dose

Alkeran, Evomela (melphalan)

- Available as IV formulations and 2 mg oral tablets
    - IV used with high dose therapy: Stem cell transplant
        - Alkeran® is dissolved in propylene glycol: use within 1 hr of preparation
        - Evomela® is formulated in cyclodextrin: Use within four hours of preparation
- Oral tablets have variable absorption
    - Store tablets in refrigerator
- Metabolism is via hydrolysis in plasma
- Half-life: 40 minutes to two hours
- Elimination: renal and fecal
    - Renal impairment may require dose reduction

Common Indications

- Multiple myeloma
- Amyloidosis
- Waldenstrom's macroglobulinemia
- Stem cell transplant conditioning regimens
    - Autologous
        - Single agent
    - Allogeneic
        - Fludarabine/Melphalan (FluMel)

Adverse Effects

- Emetogenicity
  - High dose IV
    - Moderate
  - Oral
    - Minimal-low
- Myelosuppression
  - Toxic to stem cells: Don't give to autologous stem cell transplant candidates prior to stem cell collection
- Mucositis/stomatitis
  - Cryotherapy, ice chips, prevents mucositis with high dose
- Hypersensitivity: Rare: 2% with IV formulation
- High dose therapy
  - Extravasation
  - Cardiotoxicity
  - Hepatic veno-occlusive disease
  - Pneumonitis
  - Renal toxicity
  - Seizure
  - Paralytic ileus

Dosing

- High dose: 200 mg/m^2
  - Stem cell transplant for multiple myeloma and amyloidosis
- Low dose: 4 mg/m^2 daily x 7 days every month (with prednisone)
  - Multiple myeloma
- Consider dose reduction in renal impairment

Leukeran (chlorambucil)

- Available as a 2 mg oral tablet only
  - Unstable: Refrigerate
  - Take on empty stomach
- Metabolized via liver to phenylacetic acid mustard: Active
- Half-life: 1.5 hours
- Excretion: Urine

Common Indication

- Chronic lymphocytic leukemia (CLL)
  - Single agent chlorambucil
  - Often combined with anti-CD20 monoclonal antibody
  - Typical dosing Single agent: 0.1 mg/kg/day for 3-6 weeks
    - 0.4 mg/kg pulse doses administered intermittently, biweekly, or monthly
      - Increase by 0.1 mg/kg/dose until response or toxicity

Adverse Effects

- Emetogenicity
  - PO: Minimal to low
- Myelosuppression
  - Weekly CBC while on therapy
- Seizures
  - Risk factors
    - High pulse doses
    - Nephrotic syndrome
    - Seizures
    - Head trauma
- CNS side effects
  - Agitation
  - Ataxia
  - Confusion
- Skin reactions

Bendeka (bendamustine)

- Nitrogen mustard with purine analog properties
  - Not a prodrug
  - Less cross resistance with other alkylating agents
  - Reformulated
- IV administration only
- Contraindications/precautions
  - History of anaphylactic reaction to bendamustine
  - Infection
  - Renal impairment
  - Hepatic impairment

Clinical Indications

- CLL
- Non-Hodgkin's lymphoma
- Multiple myeloma
- Waldenstrom's macroglobulinemia
- Hodgkin's lymphoma

Dosing/Administration

Typical range: 70-120 mg/m^2 IV daily on days 1 and 2 each cycle

Pharmacokinetics

- Highly protein bound
- Hepatic metabolism
- Half-life elimination
  - 30 minutes to 3 hours

- Excretion
    - Feces
        - 90%
    - Urine
        - 1-10%

Adverse Effects

- Emetogenicity
    - Moderate
- Hypersensitivity reactions
    - Antihistamine
    - Antipyretic
    - Steroids if previous reaction
- Rash
- Vesicant-like and irritant properties
    - Cold compresses

Thioplex (thiotepa)

- Ethyleneimine subclass of alkylating agent
    - Related to nitrogen mustard
    - Administered IV, intracavitary, intravesicular, or intraventricular
    - Irritant

Clinical Indications

- More common uses
    - Bladder cancer
    - CNS malignancy
    - Leptomeningeal metastases
- Less common uses
    - Malignant effusions
    - Breast cancer
    - Ovarian cancer
    - Hodgkin's lymphoma

Adverse Effects

- Emetogenicity
  - Low
  - May be higher with high dose therapy
- Myelosuppression
  - Dose-limiting
- Dermatologic side effects
  - Excreted in sweat
  - Pruritus and dermatitis
  - Skin rashes and irregular skin pigmentation
- Mucositis
- Hypersensitivity
- Dizziness
- Headache

Pharmacokinetics

- Crosses blood brain barrier
  - Cerebral spinal fluid (CSF) concentration equals plasma concentration
- Intracavitary absorption: Range 10-100% across bladder mucosa
- Extensive hepatic metabolism
- Half-life approximately 2 hours
- Excretion
  - Urine

Busulfex IV, Myleran Tablets (busulfan)

- Alkyl sulfonate subclass of alkylating agent
  - Effects on myeloid cells > lymphoid cells
  - Toxic to hematopoietic stem cells
  - Alkylates and cross-links DNA
- IV and PO administration available: 2 mg tablets
  - IV preferred for high dose therapy
    - More predictable exposure
    - Less incidence of hepatic veno-occlusive disease (VOD)

Clinical Indications

- Common use
  - Stem cell transplant conditioning
    - Busulfan/cyclophosphamide
    - Fludarabine/busulfan
- Less common uses
  - Chronic myelogenous leukemia
  - Essential thrombocytosis
  - Polycythemia vera

Doses

- High Dose
  - Stem cell transplantation
  - Oral
    - 1mg/kg PO q 6 hours
  - Intravenous
    - 0.8 mg/kg IV q 6 hours
    - 3.2 mg/kg IV once daily

Adverse Effects

- Emetogenicity
  - IV: Moderate
  - PO: Moderate to high
- Seizures
  - Prophylactic anticonvulsant beginning12 hours prior to busulfan and continued until 24 hours after last dose
- Delayed pulmonary fibrosis
- Hepatic sinusoidal obstruction syndrome (SOS) previously known as veno-occlusive disease (VOD)
- VOD

Pharmacokinetics

- Crosses blood brain barrier
  - CSF concentration equals plasma concentration
  - Seizure risk
    - Use with caution if predisposed to seizures
  - Metabolized extensively in the liver
    - Glutathione conjugation followed by oxidation
    - Acetaminophen depletes glutathione stores: Can increase busulfan levels
      - Stop all acetaminophen 72 hours before busulfan
  - Excretion
    - Urine
  - Variable pharmacokinetics
    - Measure busulfan levels to guide dose adjustments

Nitrosoureas

- Three agents
  - Carmustine (BCNU)
  - Lomustine (CCNU)
  - Streptozocin
- Lipophilic drugs
  - Cross blood brain barrier effectively

BCNU, BiCNU, Gliadel Wafers (carmustine)

- Bischloroethyl nitrosourea (BCNU, BiCNU)
- Irritant
- Significant CSF concentrations
- Mixed with sterile alcohol, then diluted for administration
    - Alcohol contributes to side effects

Clinical Indications

- Common clinical indications
    - Glioblastoma multiforme: Wafer or IV
- Lymphoma
    - Conditioning regimen prior to autologous stem cell transplant (ASCT)
- Less common indications
    - Astrocytoma
    - Brainstem glioma
    - Ependynoma
    - Medulloblastoma
    - Multiple myeloma (MM)

Adverse Effects

- IV formulation
    - Emetogenicity
        - Dose > 250 mg/m^2: High
        - Dose ≤ 250 mg/m^2: Moderate
    - Delayed pulmonary toxicity
        - High doses
    - Myelosuppression
        - Prolonged and delayed nadir
            - Dose every six weeks
    - Cardiac arrhythmia
        - High doses
    - Hypotension
        - Alcohol content
    - Flushing
        - Alcohol content
    - Vein irritation
        - Alcohol content
    - Nephrotoxicity

Pharmacokinetics

- CSF concentrations ≥ 50% of plasma concentrations
- Rapid hepatic metabolism
- Biphasic elimination
    - Initial 1.4 minutes
    - Secondary 20 minutes
    - Plasma half-life: 67 hours

- Excretion: Urine: 60-70% and lung 6-10% as CO_2

Gliadel Wafers (BCNU)

- Glioblastoma Multiforme
    - Placed in tissue cavity post-operatively
- Extended release of drug: Residual cell kill
- More CNS side effects than IV
    - Seizures
    - Hydrocephalus
    - Ataxia
    - Abnormal thinking
    - CNS infections

Gleostine (lomustine)

- Chloroethyl-cyclohexyl-nitrosourea (CCNU)
- Oral administration only: 10 mg, 40 mg, and100 mg capsules
- Common indication
    - Intracranial tumor: FDA approved

Adverse Effects

- Emetogenicity
    - PO: Moderate to high
        - Prophylactic antiemetic indicated
- Myelosuppression
    - Prolonged and delayed nadir
- Pulmonary toxicity
    - High cumulative dose
- CNS effects
- Renal impairment

Potential Prescribing Error

- Typical lomustine dose: 130 mg/m^2 PO every six weeks

A patient presented a prescription to a pharmacy for a single 160 mg lomustine dose. The pharmacist offered the patient a full package containing 20 caps (40 mg each) equals 800 mg total, since the drug is costly (to avoid waste). The patient misunderstood the instructions and took four capsules (160 mg) daily for 5 days

- Multiple similar errors have occurred, some resulting in *death*
    - Prescribe and dispense single doses only
    - Doses repeated every six weeks
    - Monitor labs; adjust subsequent doses as necessary
    - Provide patient education

Pharmacokinetics

- Oral absorption is complete
- CSF concentrations ≥ 50% of plasma concentrations
- Hepatic metabolism
- Half-life equals 16:48 hours
- Excretion: Urine (50%), feces, expired air

Zanosar (streptozocin)

- Sugar-containing nitrosourea
- High affinity for cells of the islets of Langerhans
    - Regions of pancreas that contain endocrine cells
    - Transported into cells by glucose transport proteins
- Common indications
    - Carcinoid tumor
    - Metastatic islet cell carcinoma

Adverse Effects

- Acute release of insulin
    - Hypoglycemia
- Extravasation
- Nausea/vomiting
- Elevated LFTs
- Nephrotoxicity
- Secondary malignancy
- Myelosuppression

Pharmacokinetics

- Concentrates in liver, intestine, pancreas, and kidney
- Rapid hepatic metabolism
- Half-life 35-40 minutes
- Excretion
    - Urine (60-70%), exhaled gases (5%), and feces

Temodar (temozolomide)

- A methylating agent
    - IV or PO administration
    - PO: Empty stomach
- Effectively crosses blood brain barrier
- Can be used alone or with radiation therapy
- Contraindications/precautions
    - Hypersensitivity to dacarbazine (DTIC)
    - Severe renal or hepatic impairment
    - May cause secondary malignancies

Clinical Indications

- Glioblastoma multiforme
  - Better outcomes in MGMT silenced tumors: Cannot repair temozolomide induced DNA damage
- Refractory anaplastic astrocytoma
- CNS lymphoma
- Metastatic melanoma

Adverse Effects

- Lymphopenia
- Opportunistic infections
- Nausea/vomiting
  - > 75 mg/m^2: moderate to high emetogenicity
  - ≤ 75 mg/m^2: Minimal to low emetogenicity
- Constipation
- Diarrhea
- Alopecia
- Viral infection
- Seizure
- Fatigue
- Headache

Pharmacokinetics

- Rapid and complete absorption after PO administration
  - Better/faster on empty stomach
- CSF levels 35:39% of plasma levels
- Protein binding 15%
- Prodrug: Hydrolyzed to mononuclear tumor inflammatory cells (MTIC) active drug
  - Same active metabolite as dacarbazine
- Excreted in urine/feces

DTIC (dacarbazine)

- A methylating agent: Transfers a single carbon group to DNA
- Only available IV

Indications

- Hodgkin's lymphoma
- Metastatic melanoma
- Carcinoid syndrome
- Pheochromocytoma
- Sarcoma

Adverse Effects

- Nausea/vomiting
- High emetogenicity
- Hepatotoxicity
- Seizure
- Infiltration (irritant)
- Photosensitivity
- Flu-like symptoms
- Metallic taste in mouth

Pharmacokinetics

- Hepatic metabolism to MTIC
  - Same active metabolite as temozolomide
- Half-life elimination: Biphasic
  - Initial 20-40 mins
  - Terminal 5 hours
- Excretion
  - Urine 40% as unchanged drug

Platinums

- Platinum coordination complexes
  - Cross links DNA
- Three agents
  - Cisplatin
  - Carboplatin
  - Oxaliplatin

Platinol (cisplatin)

- Platinum Agent

Indications

- Testicular cancer
- Ovarian cancer
- Bladder cancer
- Head and neck cancer
- Esophageal cancer
- Lung cancer
- Non-Hodgkin lymphoma
- Trophoblastic neoplasm

Adverse Effects

- Nephrotoxicity
  - Electrolyte wasting
  - Acute kidney injury
  - Chronic kidney disease
- Peripheral neuropathy
- Ototoxicity
  - Consider audiometric testing
- Nausea/vomiting
  - High emetogenicity
- Hypersensitivity reactions
- Syndrome of inappropriate antidiuretic hormone secretion (SIADH)
- Ocular toxicity
- Transient elevation in LFT's
- Metallic taste of foods

Miscellaneous

- Radio sensitizing agent
- Administer after Taxol (paclitaxel)
  - Prevents delayed paclitaxel excretion and increased toxicity
- To prevent nephrotoxicity, administer pretreatment hydration with 1:2 liters of IV saline solution
- Risk of ototoxicity is increased when combined with aminoglycosides and loop diuretics
- Avoid aluminum needles

Pharmacokinetics

- Renal excretion
  - Requires renal dose adjustment
  - Use caution in patients with underlying kidney disease
- Half-life: 16-53 hours
- Non-dialyzable

You are treating a 65-year-old patient with his first cycle of cisplatin. Past medical history includes hypothyroidism, coronary artery disease, BPH, and congestive heart failure (EF equals 35%). What is your biggest concern with using cisplatin in this patient?

A. Potential for nausea/vomiting
B. Potential for nausea/vomiting
C. Potential for edema/CHF exacerbation
D. Potential for edema/CHF exacerbation

Paraplatin (carboplatin)

- Platinum agent

Indications

- Ovarian cancer
- Germ cell tumors
- Head and neck cancers
- Lung cancer
- Bladder cancer
- Non-Hodgkin lymphoma
- Cervical cancer
- Testicular cancer

Adverse Effects

- Myelosuppression
- Nausea/vomiting
    - Moderately emetogenic
- Renal toxicity
- Peripheral neuropathy
- Hypersensitivity

Carboplatin Dosing

- Dose calculated to a target “area under the curve” (AUC) based on the glomerular filtration rate (GFR)
    - AUC represents total drug exposure
- Calvert formula is used to calculate dose
    - Target AUC x (GFR + 25) equals dose in milligrams
- Usual target AUC range is 5-7
    - May be lower for weekly doses, or radio sensitizing doses
    - Refer to published regimen for specific targets
- Previously treated: AUC between 4-6

Pharmacokinetics

- Renal excretion
- Half-life – 6 hours
- Removed by hemodialysis
- Not removed by peritoneal dialysis

Eloxatin (Oxaliplatin)

Indications

- In combination with 5FU/Leucovorin or capecitabine
    - Adjuvant
        - Stage III colorectal cancer
    - Palliative
        - Metastatic/Advanced colorectal cancer
- Relapsed/Refractory Non-Hodgkin's and Hodgkin's lymphoma
- Cholangiocarcinoma
- Esophageal/gastric cancer
- Pancreatic cancer

Adverse Effects

- Neurotoxicity: Dose limiting
- Myelosuppression
- Nausea/vomiting: Moderate emetogenicity
- Diarrhea
- Hypersensitivity/anaphylactic reactions

Your patient develops throat tightness, chest pain, and hypotension during his 8th round of oxaliplatin. The infusion is stopped, and he is treated with epinephrine, hydrocortisone, diphenhydramine, famotidine, and IVF and the syndrome resolves. The patient requires further treatment with oxaliplatin; how should you proceed?

A. Administer the next dose slower and with additional premedication as per order
B. Administer the dose without any changes as per order
C. Administer the next dose within a desensitization protocol as per order

Pharmacokinetics

- Metabolized in the plasma
- Renal excretion
- Half-life 16 to 17 hours

Platinum Comparison

Toxicity	Cisplatin	Carboplatin	Oxaliplatin
Radiosensitizer	XX	X	
Myelosuppression		X	
Nephrotoxicity	X		
Neurotoxicity	X		X
Ototoxicity	X		
Nausea/Vomiting	XXX	X	X

Yondelis (trabectedin)

- Derived from sea squirt

Mechanism

- Alkylating agent

Indication

- Unresectable or metastatic liposarcoma or leiomyosarcoma in patients who have received a prior anthracycline containing regimen

Dosage and Administration

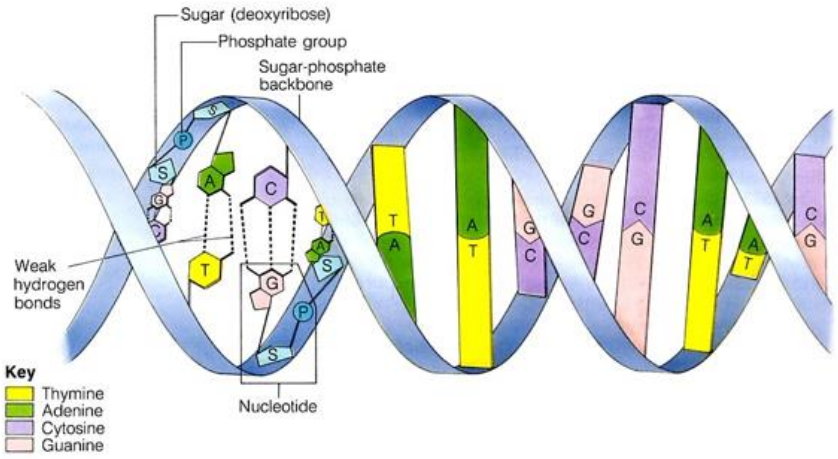
- Trabectedin 1.5 mg/m^2 infused in 500 mL of NS or D5W over 24 hours via a central line using a 0.2 micron in-line filter
- Complete infusion within 30 hours of mixing
- Premedication
  - Dexamethasone 20 mg IV 30 minutes prior to each dose
  - Additional prophylactic antiemetics (e.g. ondansetron) may be required
- Cycle length equals three weeks

Adverse Reactions

- Nausea/vomiting
  - Moderate emetogenicity
- Rhabdomyolysis
  - Monitor creatine phosphokinase (CPK) levels
- Hepatotoxicity
  - Monitor LFTs
- Cardiomyopathy
  - Monitor ejection fraction
- Extravasation
  - Vesicant

Antimetabolites

DNA Structure – Base Pairs

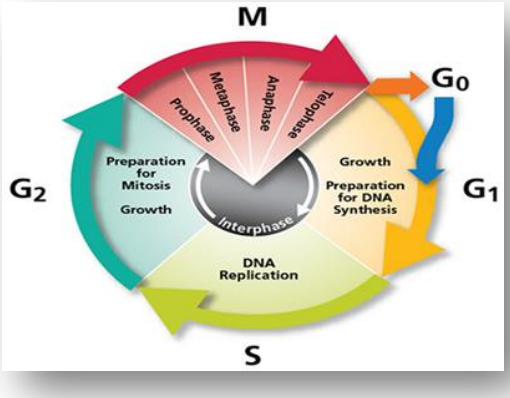


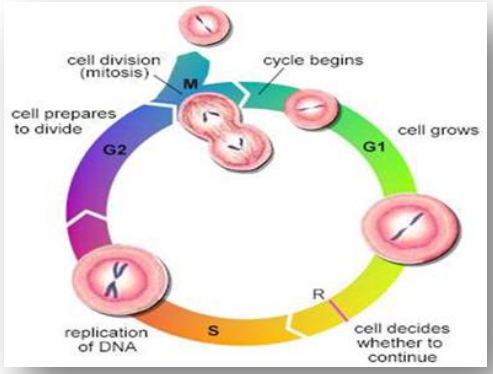
- Purines
  - Adenine
  - Guanine
- Pyrimidines
  - Cytosine
  - Thymine (DNA)/ Uracil (RNA)

What is an antimetabolite?

- Structurally related to compounds found in the body: Proteins, DNA, RNA
- Compete for binding sites on enzymes
  - Inhibit nucleotide synthesis
- Incorporate directly into DNA or RNA
  - Act as “false” nucleotides

Cell Cycle





Antifolates

- Folic acid analogs
  - Methotrexate
  - Pemetrexed
  - Pralatrexate

Pyrimidine Antimetabolites

- Fluoropyrimidines (uracil analogs)
- 5-Fluorouracil (5-FU)
- Capecitabine
- Trifluridine/tipiracil
- Floxuridine (FUDR)

Cytosine Analogs

- Cytarabine (Ara-C)
- Gemcitabine
- Azacytidine
- Decitabine

Miscellaneous

- Hydroxyurea

Purine Antimetabolites

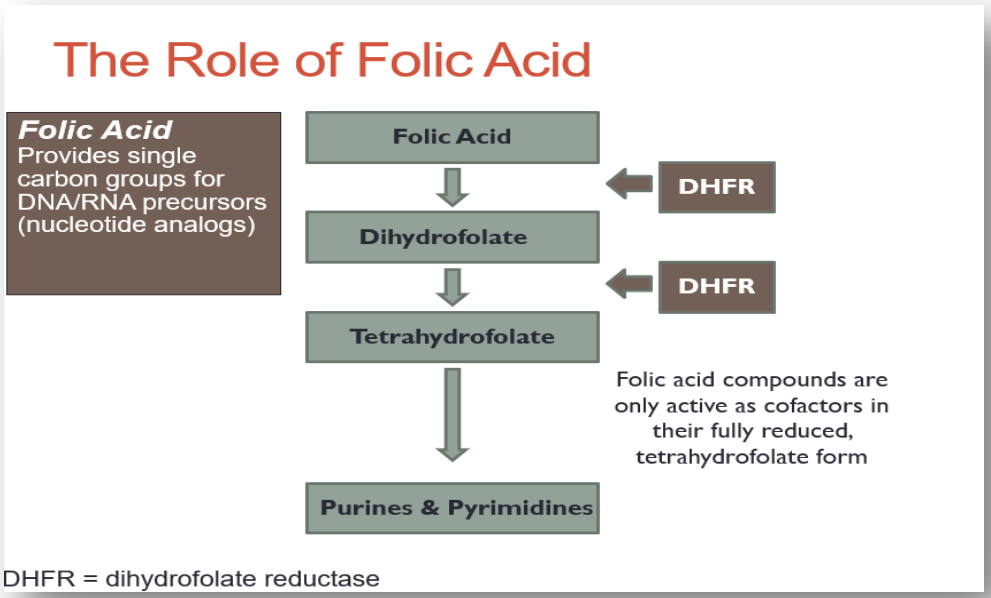
- Thiopurines (Guanine analogs)
- 6-mercaptopurine (6-MP)
- 6-thioguanine (6-TG)

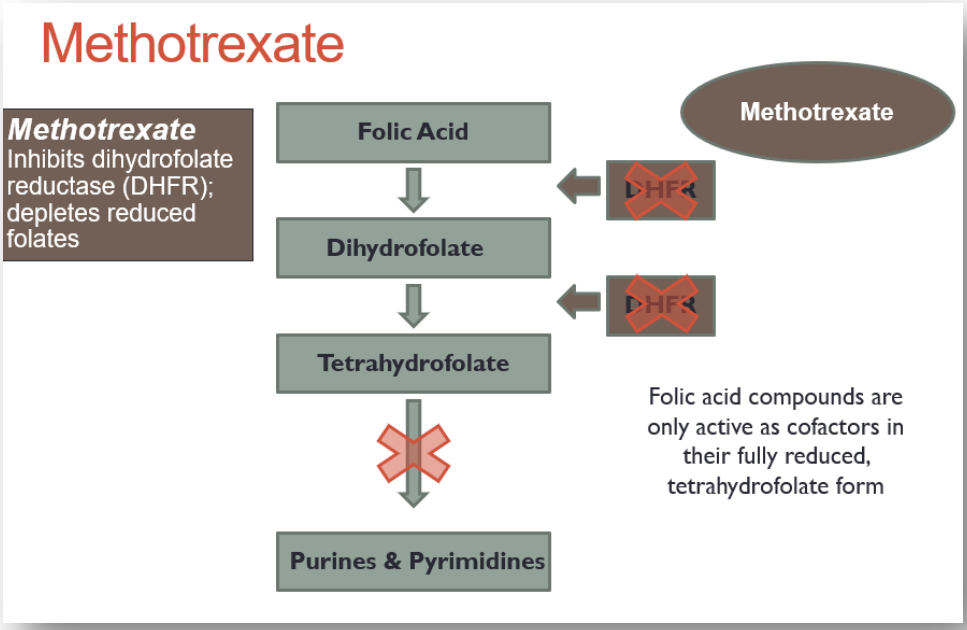
Guanosine Analog

- Nelarabine

Adenosine Analogs

- Fludarabine
- Pentostatin
- Cladribine
- Clofarabine

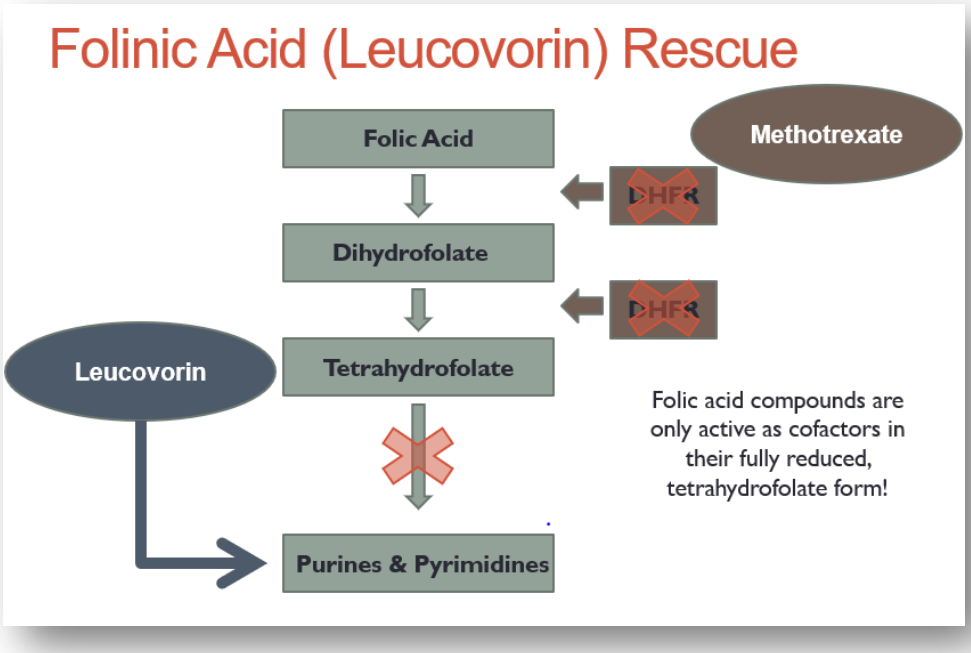

The Role of Folic Acid
Folic Acid
Provides single carbon groups for DNA/RNA precursors (nucleotide analogs)
Folic Acid
DHFR
Dihydrofolate
DHFR
Tetrahydrofolate
Folic acid compounds are only active as cofactors in their fully reduced, tetrahydrofolate form
Purines & Pyrimidines
DHFR = dihydrofolate reductase


Methotrexate
Methotrexate
Inhibits dihydrofolate reductase (DHFR); depletes reduced folates
Folic Acid
Methotrexate
DHFR
Dihydrofolate
DHFR
Tetrahydrofolate
Folic acid compounds are only active as cofactors in their fully reduced, tetrahydrofolate form
Purines & Pyrimidines

Methotrexate (MTX)

- Indication
  - Breast cancer
  - Head and neck cancer
  - Mycosis fungoides
    - Cutaneous T-cell lymphoma
  - Osteosarcoma
  - CNS lymphoma
  - CNS prophylaxis in high-risk leukemia and lymphoma patients
- Administration
  - Intravenous (IV)
  - Intrathecal (IT)
  - Oral (PO)
- Toxicity
  - Mucositis
  - Myelosuppression
  - Increase in liver function tests (LFTs)
  - Decrease in renal function
  - Pneumonitis
  - Neurotoxicity
    - Leukoencephalopathy
- Radiation recall
- Drug Interactions
  - Drugs that may increase MTX levels/delay clearance
    - Nonsteroidal anti-inflammatory drugs
    - Drugs that are highly protein bound
      - Salicylates, phenytoin, sulfonamides
  - Penicillin
  - Aminoglycosides (and other nephrotoxins)
  - Tetracyclines
  - Proton-pump inhibitors

- General Dose Adjustments
  - Renal
    - Creatinine Clearance (CrCl) ≥ 50 mL/min: Full dose
    - CrCl 10-50 mL/min: 50% dose reduction
    - CrCl < 10 mL/min: Avoid use
  - Avoid high-dose methotrexate to patients with abnormal renal function
    - High dose is > 500 mg/m^2
  - Liver
    - Bilirubin < 3.1mg/dL: Full dose
    - Bilirubin 3.1-5 mg/dL: 25% dose reduction
    - Bilirubin >5 mg/dL: Avoid use



Clinical Pearls for MTX

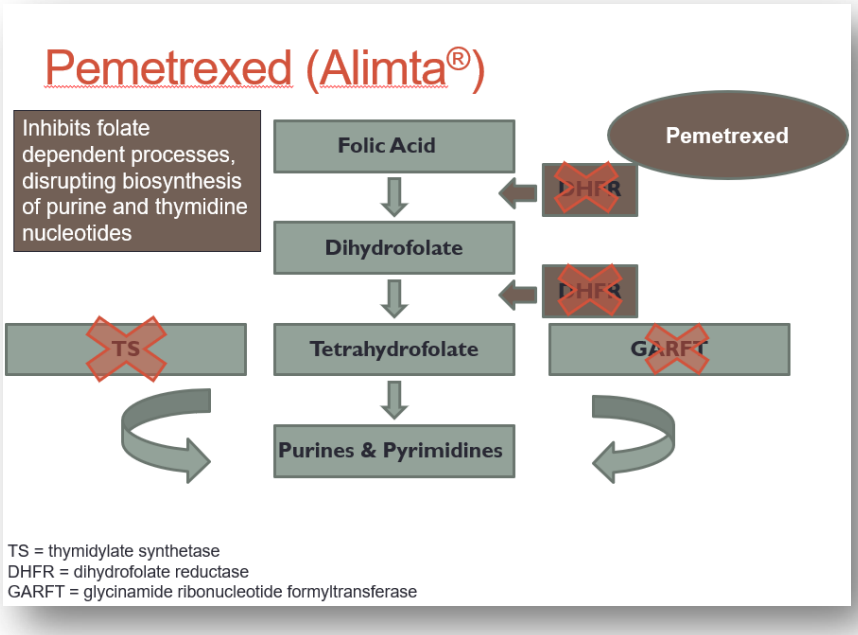
- Monitor plasma concentrations (patients receiving high-doses)
  - Samples should be drawn in a red-top vial and wrapped in foil light degrades MTX
  - Samples should be drawn daily until level ≤ 0.05μM
  - Leucovorin rescue begins ~24 hours after the end of MTX infusion
- Patients receiving high-dose MTX require alkaline urine
  - Do not administer until urine pH ≥ 7
    - Sodium bicarbonate
      - Available in both PO and IV formulations
- Methotrexate accumulates in fluid collections
  - Drain pleural effusions, ascites, etc. before giving high dose methotrexate

Your patient with CNS lymphoma who received high dose methotrexate yesterday is too nauseous to take her oral leucovorin pills. You should

A. Omit the dose and mark "patient refused" in the medical record
B. Insert an NG tube, crush tablets, and administer through the NG tube
C. Administer ondansetron and try again in an hour
D. Request an order for IV leucovorin

Voraxaze (Glucarpidase)

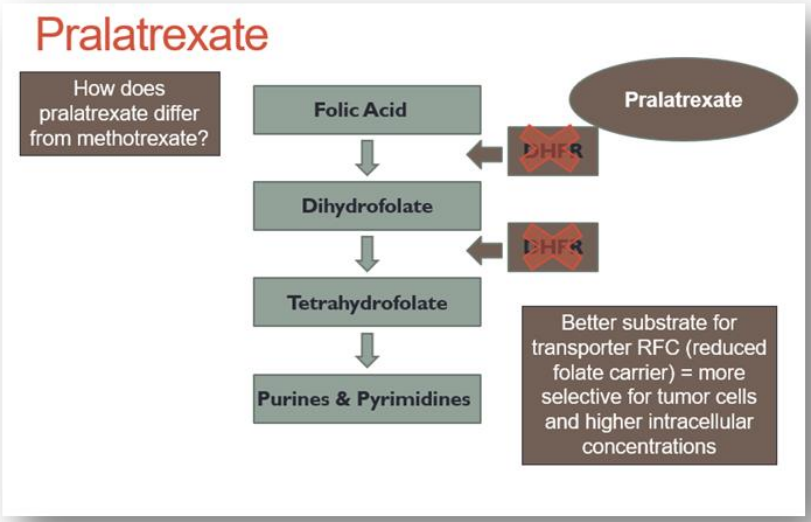
- Recombinant enzyme (carboxypeptidase)
- Indication
  - Treatment of toxic plasma methotrexate concentrations in patients with delayed methotrexate clearance due to impaired renal function



Alimta (pemetrexed)

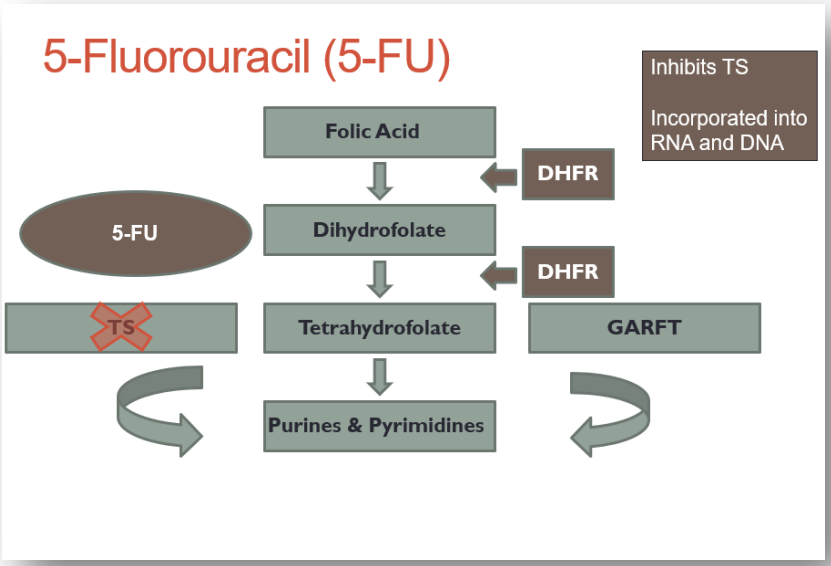
- Indication
  - Locally advanced or metastatic nonsquamous non-small cell lung cancer
    - Initial treatment with platinum agent or as maintenance chemotherapy
  - Mesothelioma
    - In combination with platinum agent
- Administration
  - IV
    - 500mg/m2 q 21 days
    - Infused over 10 minutes
- Toxicity
  - Myelosuppression
  - Fatigue
  - Nausea/vomiting
  - Stomatitis/pharyngitis
  - Rash: Premedicate

- Dose Adjustments
    - 25% Dose Reduction
        - Nadir absolute neutrophil count (ANC) < 500/mm^3 and nadir platelets ≥ 50,000/mm^3
        - Nadir platelets < 50,000/mm^3 without bleeding (regardless of ANC)
        - Any diarrhea requiring hospitalization (irrespective of Grade) or Grade 3 or 4 diarrhea
        - Any grade 3 or 4 toxicity except mucositis
    - 50% Dose Reduction
        - Nadir platelets < 50,000/mm^3 without bleeding (regardless of ANC)
        - Grade 3 or 4 mucositis
        - Patients should not begin a new cycle of treatment until
        - ANC is ≥1500 cells/mm^3
        - Platelet count is ≥100,000 cells/mm^3
        - CrCl is ≥ 45 mL/min
- Clinical Considerations
    - Premedication
        - Folic acid
            - Take folic acid 400 mcg to 1000 mcg orally once daily beginning seven days before the first dose
            - Continue throughout therapy and for 21 days after the last dose
    - Vitamin B12
        - Administer vitamin B12 1 mg intramuscularly 1 week prior to the first dose of pemetrexed and every 3 cycles thereafter
    - Corticosteroids
        - Take dexamethasone 4 mg orally twice daily for three days Pralatrexate



Folotyn (pralatrexate)

- Indication
  - Relapsed or refractory peripheral T-cell lymphoma (PTCL)
  - Administration: IV push 30mg/m^2 q week for 6 weeks in a 7-week cycle
- Toxicity
  - Myelosuppression
  - Mucositis
  - Rash
  - Hepatic toxicity
- Dose Adjustments
  - Renal or hepatic dysfunction
    - May be necessary to decrease dose to 20 mg/m^2 (also for grade 2-3 toxicity)
  - Patients should not begin a new cycle of treatment until
    - Mucositis should be ≤ grade 1
    - ANC is ≥ 1000 cells/mm^3
    - Platelet count is ≥ 100,000 cells/mm^3 for first dose and ≥ 50,000 cells/mm^3 for all subsequent doses
- Clinical Considerations
  - Premedication
    - Folic acid: Take folic acid 1.0 -1.25 mg orally once daily beginning 10 days before the first dose continue throughout therapy and for 30 days after the last dose
    - Vitamin B12: Administer vitamin B12 1 mg intramuscularly within 10 weeks prior to the first dose of pralatrexate and every 8-10 weeks thereafter



5-Fluorouracil (5-FU)

- Indication
  - Breast cancer
  - Colorectal cancer
  - Gastric cancer
  - Pancreatic cancer
  - Head and neck cancer
- Administration
  - IV push
  - IV continuous infusion
  - Topical
- Toxicity
  - Myelosuppression
  - Hand-foot syndrome: Dermatologic rash
  - Skin / photosensitivity: Radiosensitizer
  - Cardiac: Coronary spasm
  - GI epithelial ulceration: Mucositis and diarrhea
  - Ocular toxicity
- Administration
  - 5-FU IV Push
    - Increased myelosuppression
    - Decreased mucositis and diarrhea, skin toxicity
  - 5-FU Continuous Infusion
    - Decreased myelosuppression
    - Increased mucositis and diarrhea, skin toxicity

- Dose adjustments
    - Renal or Hepatic Dysfunction
        - Consider discontinuation of therapy
            - Total bilirubin > 5
    - Monitoring parameters
        - Consider discontinuation of therapy
            - Mucositis
            - Severe neutropenia
            - Severe thrombocytopenia
            - Severe nausea/vomiting
- Clinical considerations
    - Leucovorin
        - Used to enhance the effect of 5-FU
        - Leucovorin (reduced folate) ↑ levels cofactors required for ternary complex with 5-FdUMP and TS

Antineoplastic Therapy Administration

Standards and Guidelines

- Oncology Nursing Society (ONS)
  - Oncology certification
- National Comprehensive Cancer Network (NCCN)
- State Board of Nursing
  - Adequate knowledge and skills required for areas of highly specialized practice
  - Graduate nurses can administer chemotherapy in Pennsylvania (PA)
- Occupational Safety and Health Administration (OSHA)
  - Safe handling and disposal practices National Institute for Occupational Safety and Health (NIOSH) Guidelines
- Centers for Disease Control (CDC)
- American Society of Health System Pharmacists (ASHP)
- Institutional policies: The ultimate guide to practice
  - UPMC Infonet: PUH/SHY and UPMC Hillman Cancer Center Policies

Professional Qualifications

- Certification in CPR: Basic life support (BLS)
- IV therapy skills
- Educational preparation
  - Chemotherapy Course: Skills assessment and test
  - Train-the-Trainer: Yearly competency
- Advanced Cardiac Life Support Training (ACLS)

Chemotherapy Administration Process

- Informed consent
- Pre-treatment evaluation
  - Lab work, assessment, vital signs, intravenous access
  - Patient education
  - Symptoms and side effects
- Chemotherapy order writing
- Chemotherapy order verification
- Drug administration
- Patient monitoring

_____
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Informed Consent

- Physicians have a _____ and _____ responsibility to provide adequate information to the patient so that he or she can process the information and make appropriate decisions
- Consent must be _____
- Patient must be competent
- Required for standard and investigational therapy in PA
- Check institutional policy i.e., who may obtain consent
- Family member, health care professional, or another person can witness
    - The witness verifies only that the patient has signed the form, not the _____of the consent discussion
- Check institutional policy i.e., time limit on consent: one year at UPMC

Components of Consent

- Diagnosis
- Risks and benefits of treatment
- Alternative treatment options along with their risks and benefits
- The risks of refusing treatment

Pretreatment Evaluation

- Medical/surgical history
- Tumor type, stage/grade
- Recent treatment
- Psychosocial status (ECOG vs. Karnofsky)
- Nutritional status
- Performance status
- Insurance/financial issues
- Accurate and current medication list
- Fertility concerns
- Vascular access
- Allergies
- Baseline organ function as indicated
    - Multigated acquisition (MUGA) scan: Anthracyclines
    - Pulmonary function tests: Bleomycin
    - Urine collection for creatinine clearance

Focused Assessment Prior to Each Treatment

- Effectiveness of _____ regimen
- Oral cavity
- Fatigue
- Pregnancy status
- Drug-related organ toxicities
- Patency of vascular access device
- Pertinent labs
- Current _____ and _____

Patient and Family Education

- Nursing responsibility: Prepare patient for _____ - _____
- Use combination of education methods
- Educational materials
    - Drug information sheets
    - Chemotherapy booklet
    - Chemotherapy waste (excretion) information
    - Diet

Chemotherapy Dosing

- Usually based on _____ surface area (m^2) or weight
- Accurate _____ and _____ are essential
- Dosing weight may be based on ideal weight or adjusted weight rather than actual weight
    - Ideal Body Weight: Used to ensure safe dosage in the case of obesity or fluid overload purposes
    - Stem Cell Transplant (SCT) regimens
    - Adjusted Body Weight: Used if the ideal body weight and actual body weight differ by > 30%
        - Also ensures safe dosage
- Dosing weight i.e., actual, ideal, or adjusted is a physician decision

Height and Weight

- Coats, hats, and shoes must be _____
- Don't rely on information provided by the patient: Need _____ measurements
- Must be verified by two RNs for a new patient this must be documented in electronic medical record (EMR)
- Metric: Kilograms and centimeters is the correct method of measurement
- English: Pounds and inches is the correct method of measurement

_____
_____
_____
_____
_____

All calculations and formulas can be found in appendix A: Antineoplastic Therapy Formulas

Conversion Equations

Metric/English Conversions

1 kg = 2.2 lbs

kg = lbs ÷ 2.2

lbs = kg x 2.2

2.54 cm = 1 in

cm = in x 2.54

in = cm ÷ 2.54

Ideal Body Weight Calculation Formula

Male	Female
50 kg for 5 feet	45.5 kg for 5 feet
add 2.3 kg for every inch over 5 feet	add 2.3 kg for every inch over 5 feet
IBW = 50kg + 2.3 (in > 5 ft)	IBW = 45.5 kg + 2.3 (in > 5ft)
Example: 5'2"	Example: 5'2"
IBW = 50 kg + 2.3(2)	IBW = 45.5 kg + 2.3 (2)
IBW = 50 + 4.6	IBW = 45.5 + 4.6
IBW = 54.6 kg	IBW = 50.1 kg

Adjusted Body Weight Formula

- If actual body weight and ideal body weight differ by > 30%
- Used with dose intensification
- Limited data available
- Adjusted body weight = 0.25(actual body weight - IBW) + IBW
- Example
    - Actual weight: 100 kg Ideal weight: 50 kg
        - 50% difference in weight
        - Adjusted body weight = 0.25(100 – 50) + 50
        - Adjusted body weight = 0.25(50) + 50
        - Adjusted body weight = 12.5 + 50
        - Adjusted body weight = 62.5 kg

Drug Dose

- After patient's weight has been determined we need to determine the drug dose
- Drugs can be dosed based on weight or BSA
- Determine if actual, ideal, or adjusted body weight is to be used
    - Weight, actual, ideal or adjusted is determined by physician

Practice Equations

Pt is 65 inches and weighs 150 pounds

1. Body Surface Area (BSA) Calculations
   Drug Dose: BSA Based Dose
   Ifosfamide 5000mg/m^2
   BSA: _____

   Drug dose = BSA x ordered dose
   Drug dose = _____ x 5000
   Drug dose = _____

2. Weight Based Dose
   Weight: 68kg
   IL2 600,000 units/kg

   Drug dose = weight x ordered dose
   Drug dose = _____ x 600000
   Drug dose = _____ units

Carboplatin Dosing

- Calvert Formula is used to calculate the dose of carboplatin
  - Dose in mg = AUC x (GFR + 25)
- Step 1: Calculate the creatinine clearance (CrCl) from the serum creatinine
  - CrCl = glomerular filtration rate (GFR) in Calvert Formula
- Step 2: Calvert formula
  - Dose in mg = AUC x (GFR + 25)
  - Area under the curve (AUC)
- Glomerular filtration rate (GFR): Estimated from serum creatinine clearance
  - If estimating GFR, recommends that clinicians consider capping estimated GFR at a maximum of 125 mL/min
- Physician provides numerical value for the AUC in the chemotherapy order
- AUC = measure of drug exposure
  - Used to determine how long a patient should have active drug in the body
  - Higher AUC = more toxicity

Male

Step 1: Creatinine clearance

- Age: 65, Weight: 70 kg
  Serum creatinine 1.2
  - CrCl = _____

Step 2: Calvert formula

- AUC 4
- Carboplatin dose = _____

Female

Step 1: Creatinine Clearance

- Age: 65, Weight: 70 kg
  Serum creatinine: 1.2
  - CrCl = _____

Step 2: Calvert formula

- AUC 4
- Carboplatin dose = _____

General Principles for Chemo Dosing

- Always write out full name of drug
- Decimal points
  - Zero always _____ the decimal
    - Correct: 0.5 Incorrect: .5
  - Zero never _____ the decimal (trailing zeros)
    - Correct: 5 Incorrect: 5.0
- Physician or Pharmacist responsible for calculation of BSA and dose
  - No “blank” spaces
- Rounding of final dose may be done by physician or pharmacist

_____
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_____

Drug Dose Summary

- Physician determines which weight to use
  - Actual weight
  - Ideal body weight
  - Adjusted body weight
- Determine if drug is weight based vs. BSA based
- Calculate drug dose
  - Dose = drug x BSA
  - Dose = drug x weight
  - Carboplatin = use _____ formula

True or False? A patient's chemotherapy has been dose reduced due to nephrotoxicity. The patient needs a new consent.

Which of the following are used to calculate antineoplastic therapy?

A. Actual body weight
B. Adjusted body weight
C. BSA
D. All of the above

Which of the following is not associated with carboplatin dosing?

A. AUC
B. Bilirubin level
C. Calvert formula
D. Creatinine clearance

Chemotherapy Order Verification

- Performed _____ by two chemotherapy-qualified nurses
- Performed by pharmacists mixing drug
- Order is checked for potential errors or omissions
- Critical step in eliminating errors
- Review required lab studies and compare to specified treatment parameters
  - Pregnancy test
  - Complete blood count
  - Liver function tests
  - Renal function
- Compare drug dosage and schedule to the protocol, known regimen, past orders, and/or physician documentation
- Verify dosage calculations
  - Ordered dose within 10% of nurse calculations
- Review completeness of order
  - Necessary hydration and anti-emetics
  - Protectants and rescue agents
  - Hypersensitivity pre-medications
  - Monitoring: Neurological checks, urine pH, vital signs
- Ensure emergency drugs are available

_____
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- Verify physician's signature
    - UPMC: Fellow cannot write orders independently in first three months
- Verbal orders, emergency situations, order clarification, and faxed orders
    - Check your hospital policy

10% Rule

- Complete your calculation
- Determine if the physician dose is within 10% of your calculation
- Safe dose administration range:
    - Upper limit = your dose calculation x 1.1
    - Lower limit = your dose calculation x 0.90

OR

- Find 10% of your dose = 0.1 x your dose
    - Upper limit = your dose calculation + 10%
    - Lower limit = your dose – 10%

10% Rule Example

Your calculated dose: 75 mg Physician calculated dose: 100mg

Method 1:

Upper limit = 75 x 1.1
Upper limit = 82.5
Lower limit = 75 x 0.90
Lower limit = 67.5

Method 2:

10% of your dose = 75 x 0.1
10% of your dose = 7.5
Upper limit = 75 + 7.5 Lower limit = 75-7.5
Upper limit = 82.5 Lower limit = 67.5

Safe dose administration range is 67.5- 82.5 mg

Is this dose safe to administer? Yes/No

EMR Order Check

- You must check the MAR/EMR against the
    - _____ chemotherapy order sheet
    - _____ order sheet
- Ensures that there were no errors when _____ drug, doses, or administration time into the computer
- Done _____ chemotherapy administration
    - UPMC: First nurse to hang the chemo is responsible
- Documentation
    - Written orders: Redline (inpatient)
    - Electronic orders: Document that the EMR verified

_____
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True or False? The physician orders 100mg of drug X. When you calculate the patient's dose you calculate that the patient should receive 85mg of the drug. The ordered medication is ok to give to patient.

During the order verification process what information must be verified?

a. Antiemetic Regimen
b. Chemotherapy Dosing
c. Hydration
d. Schedule of Drugs
e. All of the above

Prior to Chemotherapy Administration

- Review administration procedure with patient and family
- Administer _____ to patient
- Verify pertinent lab values are in acceptable range each day of treatment, if ordered
    - Urine pH, urine heme, LFTs, renal function, etc.
- Review medication for _____ properties of drug and allergy potential
- Verify _____ with other IV medications/IVF
- Check for patent venous access

Verifying Patency of Peripheral Intravenous Access

- New intravenous sites are recommended for vesicant agents
- With limited access it may be necessary to use an existing site: Must verify patency
    - Lowering bag
    - Gentle aspiration
    - Site must be free of edema and leakage
- Use smallest gauge and shortest length catheter to accommodate prescribed therapy

Peripheral IV Sites to Avoid

- Sites of limited/obstructed flow
- Sites with _____ vascular supply
- Previous radiation therapy sites
- Bruised, edematous, or areas of phlebitis
- Sites _____ to veins that have experienced venipuncture in the past 24 hours
- The use of the antecubital and hand veins

_____
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Central Line Patency

- Central line patency may be verified by _____ aspiration of blood, dye study
  - Chest x-ray shows tip placement but not flow through catheter
  - Dye study may be needed to view flow of fluid from catheter
- Use of declotting agent
  - If absence of blood return, notify physician
  - Anticipate order for chest x-ray to verify placement
  - If placement verified, ask for an order for a declotting agent

Chemotherapy Administration: Drug Verification

- Once medication received from pharmacy two nurses check the drug against the chemotherapy order
  - Patient: Name, FIN, MRN, date of birth
  - Drug
  - Dose
  - Route
  - Time/date
- Second RN must document that information has been checked
  - Follow institutional guidelines
- Administering RN then proceeds to patient to administer chemotherapy

Chemotherapy Administration: Protective Attire

- NIOSH guidelines
  - Dictate hazard level of drug
  - Recommend protective equipment to wear for each hazard level
- Individuals who are pregnant, lactating, or trying to conceive should avoid contact with traditional cytotoxic chemotherapy agents

Oncology Drug Handling Precautions

Alitretinoin (Panretin)	Moderate	Short	A/HDP
Altretamine (Hexalen)	Moderate Manipulated Capsule-Full	Short	A/HDP
Amifostine (Ethyol)	Low	NA	SP
Anastrozole (Arimidex)	No Manipulated Tablet-Low	NA	SP
Arsenic Trioxide (Trisenox)	Full	Short	A/HDP
Asparaginase (Elspar)	Full	Long	A/HDP
Asparaginase *Erwinia chryanthemi* (Erwinaze)	Full	Long	A/HDP

Precaution Summary Index :
Risk Level:

Full = 2 pairs antineoplastic /hazardous drug gloves & gown	Moderate = 1 pair antineoplastic /hazardous drug gloves	Low = 1 pair nitrile gloves	No = No requirement

Intravenous Administration Safety

- Nurse attire for standard cytotoxic antineoplastic agents
    - Approved _____ gown made of polyethylene-coated polypropylene with closed front, long sleeves with elastic or knit cuffs
    - _____ pairs of disposable powder-free approved chemotherapy gloves (one glove under cuff of gown and one over)
- Use disposable, absorbent, plastic-backed pad _____ intravenous push work area to absorb droplets of the drug that may inadvertently be spilled on work surface
- Use syringes and intravenous sets with on-guard fittings or locking devices
- Reinforce with tape as necessary

Oral Chemotherapy Safety

- Wear _____ approved for chemotherapy
- Family member/friends should be instructed not to touch pills
- _____ break or open capsules

IV Chemotherapy Administration

- At bedside, RN checks patient using three identifiers
- Wash hands
- Don protective attire
- Administer chemotherapy
    - _____ first
    - Push first
    - Shorter infusions first
    - If unsure of order of administration, check with physician and/or pharmacy
- Second RN check must occur at bedside
    - Second RN must be the nurse that checked the drug against the order
    - _____ verify correct patient and correct pump rate
    - Second nurse must sign EMAR/MAR

_____
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Intravenous Push

- Two RN check: Verification of correct patient and dose at the _____
- Instruct patient on signs and symptoms to watch for and question them about symptoms periodically
- Recheck vein patency
- Open clamp of compatible IV solution until increased flow is seen to dilute agent during administration
- Do not administer directly through hub of intravenous catheter
- Cannula inserted at y-site closest to patient
- Push slowly enough to permit some IV solution to flow along with drug
- Do not inject faster than _____/_____
- Check blood return every _____ to _____ cc of the drug
    - Stop for signs of extravasation
- Flush line when complete
- Dispose of all material in the appropriate container

Intravenous Infusion

- Two RN check: Verification of correct patient and dose at the _____
- Connect infusion directly to intravenous catheter or to y site (closest to patient) through a maintenance solution
- Second nurse must verify _____ settings and tubing connections
- Continuous infusion of vesicants must be through a _____ _____
- Monitor Intravenous site throughout infusion as per policy
    - Vesicant infusions require more frequent monitoring

Small Volume Infusions

- Consider need to flush tubing if total volume of chemotherapy is less than 50 ml
- Hang flush mini-bag at upper y-site on tubing do not risk exposure by un-spiking chemotherapy bag to hang flush bag

Leaving Chemotherapy Area

- Hang “High Alert Medication” sign on IV pump
    - If something happens to patient while they are not on the floor, this sign alerts untrained staff to the hazardous nature of chemotherapy
- Avoid with _____ infusions
- Alert receiving area of chemo infusion
- Consider need to interrupt chemotherapy if patient going for procedure or surgery

_____
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Oral Chemotherapy Administration

- Chemotherapy drug should be placed in _____ medicine cup than any other medications
- Watch the patient take the drug
- Give patient emesis basin: If patient does vomit, you must check emesis to see if drug has been vomited
    - If drug has been vomited, notify physician for further instruction

_____
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_____

Antitumor Antibiotics

Two Classifications

- Anthracyclines
  - Doxorubicin
  - Daunorubicin
  - Epirubicin
  - Idarubicin
  - Mitoxantrone
    - Anthracenedione
- Miscellaneous Agents
  - Actinomycin D or Dactinomycin
  - Bleomycin
  - Mitomycin C

Anthracyclines

- Natural products
  - Actinobacteria *Streptomyces peucetius*
- Share a common, four-membered anthracene ring complex with attached sugar portion
  - Ring complex: Chromophore
  - Intense colors: Red, orange, yellow
- Widest range of clinical use in oncology
- Frequently used in combination with other chemotherapeutic agents

Mitoxantrone (anthracenedione)

- Three-membered anthracene ring complex
  - No sugar group attached
- Intense blue color

Mechanism of Action

- DNA intercalation
  - Flat, planar molecules insert into double-helix of DNA lead to structure changes
- Oxygen free radicals formed
  - Quinone structure enhances reduction-oxidation reactions, promoting free radicals
- Target topoisomerase II
  - Accumulate double and single-DNA strand breaks

Drug Resistance

- Drug efflux pumps
- Topoisomerase II point mutations
- Topoisomerase II down regulation
- Enhanced expression of different forms of topoisomerase II
    - Alpha
    - Beta

Pharmacokinetics

- Extensive tissue binding
    - Distribute rapidly to all body tissues, except in the central nervous system (CNS)
    - 75% protein bound in plasma
- Half-life: 20-30 hours
- Metabolized in liver and excreted in bile
- Urine: < 10% eliminated
    - Enough to color urine

Toxicity

- Myelosuppression: Acute, dose limiting
    - Leukopenia, thrombocytopenia, and anemia
- Moderate to severe nausea/vomiting
    - Premedication is vital
- Alopecia: Total
- Mucositis
- Infertility
- Cardiac toxicity: Acute and chronic

Cardiac Toxicity

- Acute cardiotoxicity
    - First 24 hours after drug administration
    - Not appear to be dose related
    - Self-limited
    - Rhythm disturbances
        - ST-T wave changes
        - Sinus tachycardia
        - Ventricular premature beats
    - No increase risks of future events
- Chronic cardiotoxicity
    - Dose-limiting toxicity
    - Attributed to free radical formation within heart muscle
        - Disrupts excitation and contraction

- Chronic cardiotoxicity risk factors
    - Total dose
    - Schedule
    - Previous chest irradiation
    - Elderly and very young
    - Females
    - History of cardiac disease/hypertension
    - Concurrent cytotoxic drugs with cardiac toxicity
        - Trastuzumab (Herceptin®), paclitaxel, cyclophosphamide
- Cardiotoxicity prevention
    - Scheduling
        - Bolus vs continuous IV infusion
    - Zinecard, ICRF-187 (dexrazoxane)
        - Only FDA approved agent
        - Disrupts iron-anthracycline complex and prevents reactive free radical formation
- Monitoring for cardiotoxicity
    - MUGA
        - LVEF > 50%
        - 15% decrease from baseline = Caution
- Signs and symptoms of congestive heart failure (CHF)
    - Shortness of breath (SOB)
    - Decrease in activity (DOE)
    - Peripheral edema
    - Enlarged heart

Treatment Options for Anthracycline Cardiotoxicity

- Stopping and/or changing therapy
- Standard of care for CHF
    - ACE inhibitors
    - Angiotensin receptor blockers (ARB)
    - Diuretics
    - Beta-blockers
    - Digoxin
    - Nitrates
    - Hydralazine

Extravasation

- Deep ulceration with necrosis
    - Raised red edges and necrotic centers
    - Heal slowly, if at all
- Management
    - Standard of Care: COLD compress
    - Application of ICE to site
        - 30-60 minutes: Alternate off/on for 15 minutes X 24 hours
        - Elevate/rest extremity X 24-48 hours
    - Anecdotally useful is topical dimethylsulfoxide (DMSO)
- Totect (dexrazoxane)
    - Anthracycline extravasation
    - 1000 mg/m^2 IV day 1, and day 2, 500 mg/m^2 IV day 3
        - Maximum dose 2000 mg day 1 and 2, 1000 mg day 3
        - Administer over 1-2 hours
    - Treatment on days two and three should start same time as on the first day
    - Administered within six hours of the extravasation
    - Cold compresses should be discontinued at least 15 minutes prior to initiation

Which of the following side effects must be monitored prior to starting therapy and during therapy with anthracyclines?

A. Hand-Foot syndrome
B. Cystitis
C. Cardiotoxicity
D. Pulmonary toxicity

Which of the following is the major route of metabolism with anthracyclines?

A. Kidney
B. Liver
C. Lungs
D. Intracellular

Adriamycin (Doxorubicin)

Indications

- Hodgkin’s lymphoma, non-hodgkin's lymphoma (NHL), multiple myeloma
- Lung, ovarian, breast, gastric, thyroid, sarcoma, and pediatric cancers

Route of Administration

- IV push IV infusion, IV continuous infusion, hepatic arterial infusion

Dosing in Organ Dysfunction

- Dose reduce in hepatic dysfunction
- Based upon bilirubin
    - Bilirubin 1.2-3 mg/dl: Reduce dose 50%
    - Bilirubin 3.1-5 mg/dl: Reduce 75%
    - Bilirubin > 5 mg/dl: Omit dose

Cardiac Toxicity

- Most thoroughly characterized in class
- Cumulative dose: 400-550 mg/m^2

Additional Adverse Effects

- Red urine
- Hyperpigmentation of nail beds
- Tissue vesicant
- Facial flushing: Infusion too fast

Incompatibilities

- Heparin, dexamethasone, 5-FU, sodium bicarbonate, hydrocortisone, furosemide

Skin Reactions

- Dermatologic “flare”
    - During or immediately after injections
    - Redness and urticaria up the vein
    - Self-limiting: Approximately 30 minutes

Radiation Recall

- Reactivation of skin damage in sites of previous radiation therapy

Cerubine (daunorubicin)

Indications

- Induction therapy for AML
- ALL

Route of Administration

- IV push, IV infusion
- Dosing in organ dysfunction

Dose Reduce in Hepatic Dysfunction

- Based upon bilirubin
- Severe renal dysfunction
- Creatinine > 3 mg/dL: Administer 50% of dose

Dosing Adjustment
- Bilirubin 1.2-3 mg/dl or AST 60-180 IU: Reduce dose 25%
- Bilirubin 3.1-5 mg/dl or AST > 180 IU: Reduce dose 50%
- Bilirubin > 5 mg/dl: Omit dose

Similar Potential for Cardiac Toxicity
- Total dose: 400 - 550 mg/m^2
    - Limited use (leukemia)
        - Clinically important cardiomyopathy is uncommonly seen

Incompatibilities
- Dexamethasone
- Heparin
- Sodium bicarbonate
- 5-FU

Idamycin (idarubicin)

Indications
- Developed for treatment of AML
- Induction therapy for AML in adults

Route of Administration
- IV push over 10-15 minutes
- Dose: 12 mg/m^2/day for 3 days

Dosing in Organ Dysfunction
- No specific dose adjustments are recommended
- Less cardiotoxic toxicity than doxorubicin or daunorubicin in equivalent doses
    - Cumulative dose up to 150 mg/m^2

Other Adverse Effects
- Reddish urine
- Elevations in bilirubin and transaminases

Incompatibilities
- Dexamethasone
- Heparin
- Hydrocortisone
- Etoposide
- Methotrexate
- Vincristine
- 5-FU

Ellence (epirubicin)

Indications
- Breast cancer

Route of administration
- IV push over 3-5 minutes

Dosage in organ dysfunction
- Dose reduce in hepatic dysfunction
- Based upon bilirubin or liver enzymes

Dosing Adjustments
- Bilirubin 1.2-3 mg/dl or AST 2-4 times ULN: Reduce dose 50%
- Bilirubin > 3 mg/dl or AST > 4 times ULN: Reduce dose 75%

Less cardiotoxic than doxorubicin
- Increase risk: Cumulative doses > 900 mg/m^2

Incompatibilities
- Heparin
- Alkaline pH solutions
- 5-FU

Doxil (liposomal doxorubicin) and DaunoXome (liposomal daunorubicin)
- Drug within liposome is protected from systemic degradation
    - Liposomes: Microscopic vesicles composed of a phospholipid bilayer that encapsulate active drugs
- Delivered in higher amounts to target tissues
- Cardiac toxicity is substantially less
- Extravasation injuries are less

Indication
- AIDS related Kaposi's Sarcoma, ovarian cancer, and breast cancer
- Newest indication: Multiple myeloma

Route of Administration
- IV infusion
- Initial rate: 1 mg/minute to minimize infusion reactions
    - Flushing, dyspnea, edema, fever, chills, rash, bronchospasm, and hypotension
    - Treatment: Slow infusion rate

Other Adverse Effects

- Palmer-plantar erythrodysesthesia
  - Dose adjustments
- Stomatitis
  - Dose adjustments
- Dosing in organ dysfunction
  - Based on bilirubin or liver enzymes

Doxil Dosing Adjustments

- Bilirubin 1.2-3 mg/dl: Reduce dose 50%
- Bilirubin > 3 mg/dl: Reduce dose 75%

DaunoXome (liposomal daunorubicin)

Indications

- First-line treatment for advanced HIV-associated Kaposi's Sarcoma

Route of Administration

- IV infusion

Dosing in Organ Dysfunction

- Adjust for impaired renal function
  - Creatinine > 3 mg/dL: 50% of dose
- Hepatic impairment based on bilirubin

Dosing Adjustments DaunoXome

- Bilirubin 1.2-3 mg/dl: Reduce dose 50%
- Bilirubin > 3 mg/dl: Reduce dose 75%

Vyxeos (liposomal daunorubicin and cytarabine)

- Acute myeloid leukemia: Newly diagnosed for therapy-related AML [t-AML] or AML with myelodysplasia-related changes [AML-MRC]
- Induction first cycle: Daunorubicin 44 mg/m^2 and cytarabine 100 mg/m^2 (liposomal) on days 1, 3, and 5
- Induction second cycle in patients who do not achieve remission with first cycle*:* Daunorubicin 44 mg/m^2 and cytarabine 100 mg/m^2 (liposomal) on days 1 and 3; the second induction cycle may be administered 2 to 5 weeks after the first induction cycle
  - If no unacceptable toxicity with previous cycle
- Consolidation: Daunorubicin 29 mg/m^2 and cytarabine 65 mg/m^2 (liposomal) on days 1 and 3; administer the first consolidation cycle 5 to 8 weeks after the start of the last induction; administer the second consolidation cycle 5 to 8 weeks after the start of the first consolidation cycle

- IV administration over 90 minutes (for induction and consolidation cycles) via an infusion pump through a central venous or peripherally inserted central catheter
    - Do not use an in-line filter
    - Flush the line with NS or D5W after infusion

Novantrone (mitoxantrone)

- Anthracenedione
    - Synthesized for comparable antitumor activity to doxorubicin and improved safety profile
- Intercalating topoisomerase II inhibitor
    - Potential for free radical formation is less than with anthracyclines

Indications

- AML, NHL, breast cancer, prostate cancer
- Multiple sclerosis

Route of Administration

- IV push and infusion

Dosing in Organ Dysfunction

- No specific dose adjustments
- Moderate hepatic dysfunction
    - May dose reduce based on bilirubin

Cardiac Toxicity

- Reduced secondary to less free radicals
- Total cumulative dose: 160 mg/m^2

Ulceration with Extravasation

- Reduced because less free radicals
- Classified as vesicant

Other Toxicities

- Less than anthracyclines
- Blue-green discoloration of urine
- Blue tint to eyes and skin
- Alopecia: Selective for gray hair
- Jaundice, transient LFT increase

Incompatibilities

- Heparin, hydrocortisone

Anthracycline Review

- PRE-treatment
  - MUGA
  - Total dose
  - Total bilirubin
  - N/V
  - Infertility
  - Line access
  - Extravasation
    - Treatment: COLD compress
- Post-treatment
  - N/V
  - Bone marrow function
  - Cardiac toxicity
  - Alopecia
  - Mouth care

Valstar (valrubicin)

- Carcinoma in situ of bladder, BCG-refractory disease, in patients not candidates for immediate cystectomy
- 800 mg INTRAVESICALLY once weekly for 6 weeks; solution should be retained for 2 hours (when possible) prior to voiding; delay therapy for at least 2 weeks after transurethral resection and/or fulguration

Precautions

- Bladder perforation or compromised bladder mucosa integrity
  - Delay therapy until bladder integrity is restored
- Cystectomy delay could lead to the development of metastatic bladder cancer; consider cystectomy if no complete response after 3 months of therapy
- Irritable bowel symptoms, severe; bladder spasm and spontaneous discharge of valrubicin instillate may occur
- Transurethral resection and/or fulguration; do not administer intravesical valrubicin within two weeks of transurethral resection and/or fulguration

Administration

- Use non-DEHP containing administration sets
- Insert urethral catheter and drain bladder; instill diluted solution slowly via gravity flow over several minutes
- Withdraw catheter; patient should void bladder after two hours

Adverse Effects

- Bladder pain, cystitis
- Dysuria, hematuria
- Incontinence, increased frequency of urination, nocturia
- Pain in urethra, spasm of bladder, urgent desire to urinate, urinary retention
- Urinary tract infectious disease

Cyclophosphamide, mitoxantrone, vincristine, prednisone (CNOP) could be used instead of cyclophosphamide, doxorubicin, vincristine, prednisone (CHOP) for which of the following organ dysfunctions?

A. Liver
B. Heart
C. Kidney
D. Lungs

Miscellaneous Antitumor Antibiotics

Cosmegen (Actinomycin D or Dactinomycin)

- First actinomycin antibiotic isolated from *Streptomyces* species in the 1940s

Mechanism

- Inhibits DNA and especially RNA synthesis
- Intercalates into DNA
- Generation of DNA strand breaks via interaction with topoisomerase II

Resistance

- Decreased drug accumulation within cells
- Overexpression of the multi-drug resistant (MDR) gene

Indications

- Pediatric tumors
- Sarcomas, testicular cancer, Wilm's tumor
- Potent radiation sensitizer

Pharmacokinetics

- Half-life 36 hours
- 20% excreted in urine and 13% in feces

Route of Administration

- IV push: 10-15 minutes

Toxicity

- Myelosuppression
  - Dose-limiting
  - Severe neutropenia and thrombocytopenia
  - Prolonged nadir: Delayed as long as 3 weeks
- Nausea/vomiting
  - Highly emetogenic
  - Can get worse each day
- Liver toxicity
- Diarrhea
- Alopecia
- Skin
  - Acne, rash, hyperpigmentation
- Fatigue
  - Extravasation: COLD compress
- Stomatitis
- Gastrointestinal pains

Doses

- Almost always in MICROGRAMS
- Dosing in organ dysfunction
  - No renal adjustment
  - Minimal hepatic metabolism: No adjustment

Blenoxane (Bleomycin)

- Mixture of cytotoxic glycopeptide antineoplastic antibiotics
  - Bleomycin A_2 (70%) and bleomycin B_2
  - Isolated from the fungus Streptomyces verticillus
- Strength is expressed in units of drug activity
  - Bleomycin 1 mg = 1 unit
- DNA-binding region and iron-binding are at opposite ends of the molecule

Mechanism

- Requires binding of an iron-bleomycin complex to DNA
- Complex reduces O_2 to free oxygen radicals
- Oxygen free radicals: Lead to single and double strand DNA breaks
- Greatest effect on G2 phase of cell cycle

Mechanism corresponds to toxicities

- Lung toxicity

Resistance

- Drug inactivation by increased expression of catabolic enzyme called bleomycin hydrolase
  - Low amounts in skin and lung: Toxicities
- Increased expression of DNA repair enzymes
- Decreased drug accumulation via decrease drug uptake in cell

Indications

- Hodgkin's lymphoma, NHL, germ cell tumors, squamous cell of head and neck cancer, squamous cell of skin, cervix, vulva, and penis
- Sclerosing agent for malignant pleural effusions and ascites

Pharmacokinetics

- Eliminated renally: 45-70% in urine at 24 hours
- Half-life 2-4 hours
  - Renal failure: 20 hours
- Low protein binding

Toxicity

- Myelosuppression/immunosuppression
  - Mild
- Fever and chills
  - Schedule acetaminophen for 24 hours
- Mucocutaneous toxicity
  - Dose dependent
  - Mucositis, erythema, hyperpigmentation, alopecia, thickening of nail beds
  - Skin peeling leading to ulceration: 2^{nd} to 3^{rd} week
- Mild nausea/vomiting
- Severe idiosyncratic reaction: Up to 30%
  - Increased in lymphoma patients
  - Similar to anaphylaxis
  - Hypotension, confusion, fever, chills, wheezing
  - Immediate or delayed for several hours

Treatment

- Volume expansion, vasopressors, antihistamines, steroids
- Give test dose
  - Give $\leq$ 2 units of bleomycin for the first two doses
  - Monitor vital signs every 15 min
  - Wait one hour before giving remainder of dose

Lung Toxicity

- Dose limiting: > 400 units or single dose > 30 units
- Acute or chronic interstitial pneumonitis with interstitial pulmonary infiltrates
- Lung cell damage to vasculature from induction of cytokines and oxygen free radicals
    - Cannot move air from lung damage
- Why lungs?
    - MOA of bleomycin + high oxygen in lungs = TOXICITY
- Symptoms
    - Cough/SOB
    - Crackles
    - Infiltrates on CXR
- Risk factors
    - Dose
    - Age > 70
    - Underlying lung disease
    - Prior irradiation to chest
    - Exposure to high concentration of oxygen
    - Renal impairment
- Prevention
    - Pulmonary function tests at baseline and with each cycle
    - Decrease bleomycin if decrease > 15% in either diffusion capacity of CO_2 or vital capacity

Route of Administration

- Oral bioavailability is poor
- IV infusion, IV push, SC, or IM routes
- Intracavitary route for malignant pleural effusions and/or ascites
    - 45-55% absorbed systemically

Dosing in Organ Dysfunction

- Renal impairment

Incompatibilities

- Amino acid solutions, cefazolin, cisplatin, cytarabine, hydrocortisone, methotrexate, mitomycin, PCN, nafcillin, diazepam, furosemide

Dose Adjustments

- Creatinine Clearance: Reduce dose 25%
- Creatinine Clearance: Reduce dose 75%

Mutamycin (mitomycin C)

- Extracted from *Streptomyces* species
- Aziridine agent related to nitrogen mustards

Mechanism of Action

- Acts like an alkylating agent
- Produces DNA cross linking
- Cell cycle non-specific
- Inhibits DNA and RNA synthesis

Pharmacokinetics

- Hepatic metabolism
- Half-life 23-78 minutes
- High concentrations found in kidney, tongue, muscle, heart, and lung tissue

Route of Administration

- IV infusion, IV push
- Flush with 5-10 mL of IV solution before and after drug administration

Indications

- Breast cancer, colorectal cancer, esophageal cancer, gastric carcinoma, pancreatic cancer

Dosing in Organ Dysfunction

- Renal adjustments may be indicated
- Consult individual protocols

Toxicity

- Myelosuppression
  - Prolonged nadir for 4- 6 weeks
  - Cumulative effects
- Cardiotoxicity: CHF in 3% -15%
  - Doses > 30 mg/m^2
- Alopecia
- Interstitial pneumonitis
- Nail discoloration
- Nausea/vomiting
- Hemolytic uremic syndrome (HUS)
  - Renal failure
- Extravasation
  - Potent vesicant can lead to ulceration
- Neurotoxicity
  - Paresthesias

Extravasation Management

- Observe closely
- Few agents effective as antidotes
    - Dimethylsulfoxide (DMSO) may help
- Delayed dermal reactions are possible

Miscellaneous Antitumor Antibiotics: Review

Cosmegen (actinomycin D/dactinomycin)

- Pre-treatment
    - N/V Worse each day
    - Extravasation COLD
    - Dose in micrograms
- Post-treatment
    - Nausea/vomiting
    - Bone marrow function
        - Prolonged nadir
    - Diarrhea / GI
    - Alopecia
    - Rash

Blenoxane (bleomycin)

- Pre-treatment
    - PFTs
- Severe idiosyncratic reactions
    - TEST DOSE
        - Renal function
        - Fevers/chills
- Post-treatment
    - Lung Toxicity
    - Skin
    - Alopecia
    - Mucocutaneous toxicity

Mitomycin C

- Pre-Treatment
    - Renal function
    - Extravasation
- Post-Treatment
    - Bone marrow function
    - Prolonged nadir
    - Hemolytic uremic syndrome (HUS)
    - Cardiac toxicity
    - Alopecia

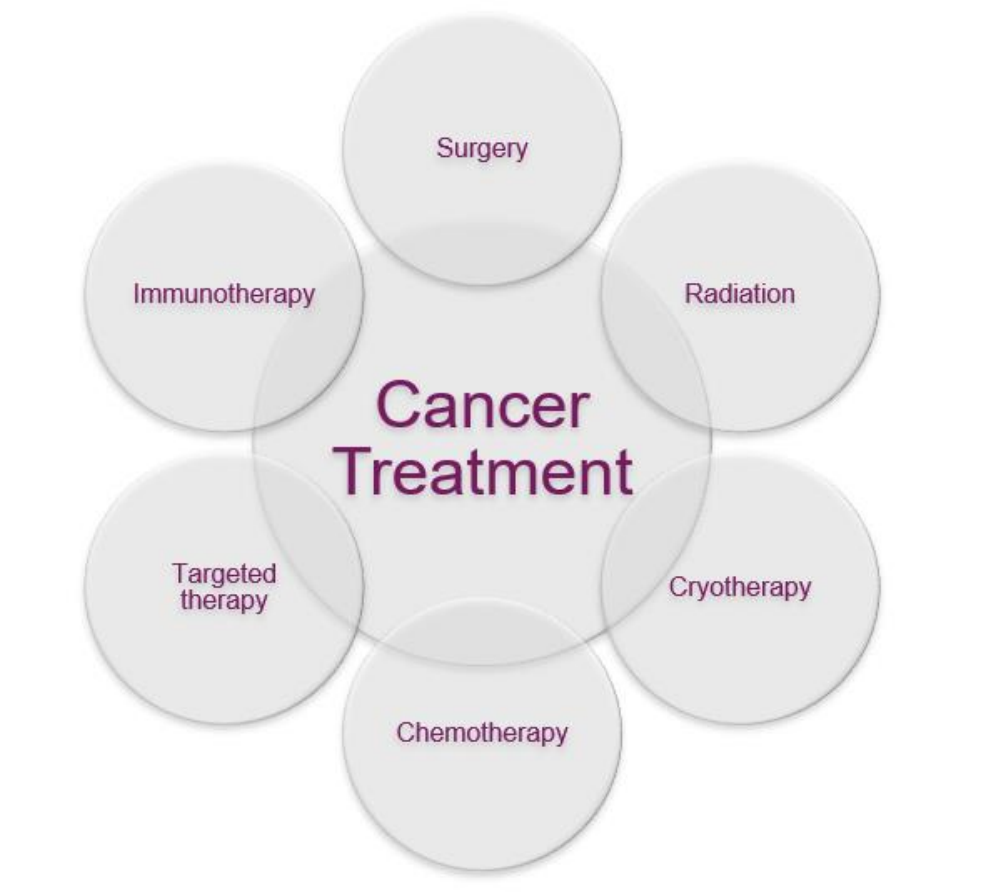
A patient on bleomycin must be monitored for which of the following?

A. Liver toxicity
B. Cardiac toxicity
C. CNS toxicity
D. Pulmonary toxicity

A patient getting IV doxorubicin has line access issues and unfortunately, an extravasation event has occurred. Which of the following is best to manage the event?

A. Apply cold packs and have patient move/bend arm frequently
B. Apply cold packs and have patient rest extremity
C. Apply cold packs and SQ dexrazoxane
D. Apply hot packs and IV dexrazoxane

CAR T Therapy



Immunotherapy

- Strong relationship between immune system evasion and cancer cell proliferation
- Aim to modulate the patients' immune system against malignant cells
- Rationale
    - Reduce toxicity, increase specificity, and outcomes compared to traditional chemotherapy

Immunotherapy

Cancer Vaccines	• Gp100-209-2017(210M) peptide vaccine • Sipuleucel-T (Provenge)
Adoptive Cellular Immunotherapy	• Chimeric antigen receptor (CAR T cells) • Tumor infiltrating lymphocytes (TIL)

Immune Checkpoint Blockade	• Anti-CTLA-4 antibody
	  ○ Ipilimumab
	  ○ Anti-PD1 antibody
	  ○ Nivolumab, pembrolizumab
	  ○ Anti-PD-L1 antibody
	  ○ Atezolizumab, avelumab, durvalumab

Oncolytic Viruses	• Talimogene laherparepvec (T-VEC)

Adoptive Cellular Immunotherapy

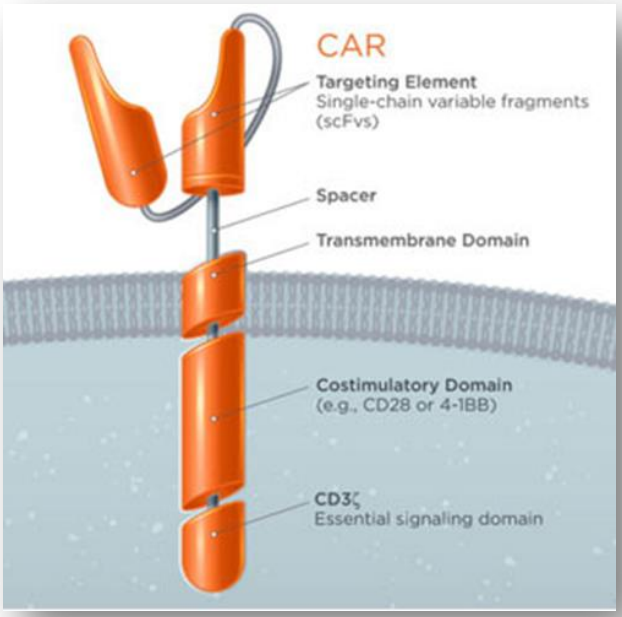
- Utilizes natural anti-tumor properties of lymphocytes
- Autologous lymphocyte re-infusion following lymphodepleting chemotherapy
- Shown to have activity in both hematologic and oncologic malignancies

CAR T Therapy

- Immunotherapy comprised of genetically altered T-cells that can recognize malignant cells
    - T-cells are derived from the blood and must be genetically altered in order to elicit their effect
- Comprised of two primary components
    - Chimeric antigen receptor (CAR)
    - Patient-specific T-lymphocytes

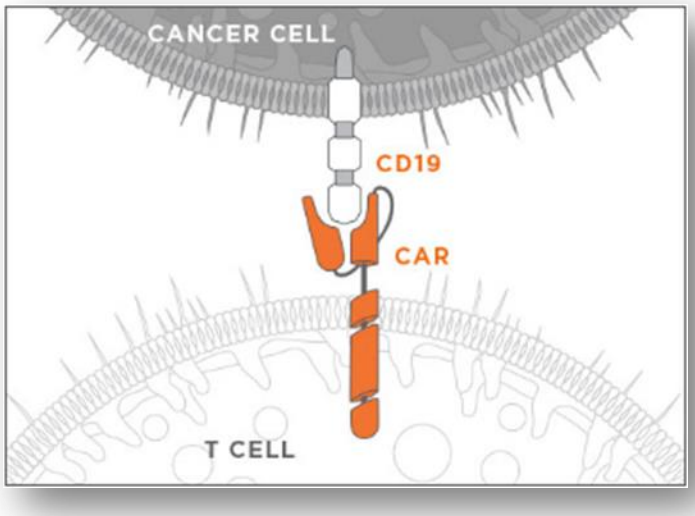
CAR

- Receptor composition
    - Specific binding domains from tumor targeting antibody
        - T-cell signaling domains
- Allows targeted antibody redirected T cell activation



CAR T-Cell

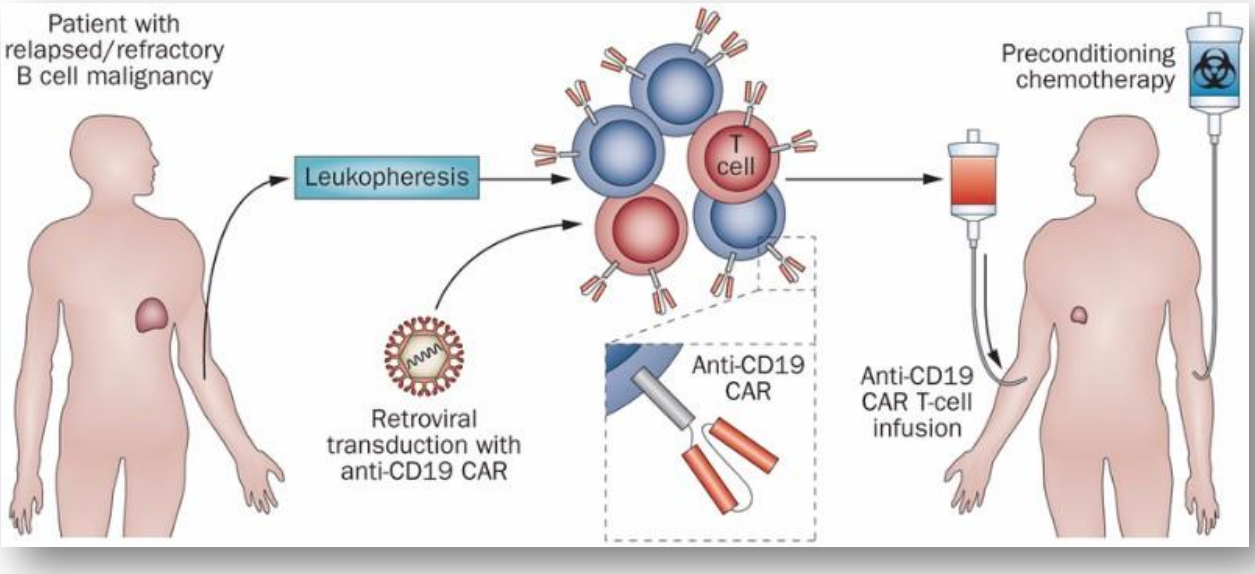
- Once the CAR has been created, T-cells can be engineered to express CAR by gene transfer
  - Utilizes retroviral vectors
- CAR T-cell mechanism
  - Recognize their target antigen
  - Result in T-cell activation towards specific target antigen



CAR T Manufacturing Process

- Patient deemed eligible for CAR T therapy
- T cells are extracted from the patient's blood T-cells engineered to express CAR and replicated
- Patient receives T-cell depleting Chemotherapy
- CAR-T cells reinfused into patient

CAR T Manufacturing Process



CAR T Overview

- Cell utilized
  - T-Lymphocytes
- Patient specific
- Genetic alteration
- Conditioning regimen
  - Cyclophosphamide/Fludarabine
- Timeframe needed
  - Three to four weeks
- FDA approved indications
  - Relapse/refractory large B-cell lymphoma
  - Relapse/refractory B-cell acute lymphoblastic leukemia (ALL)

Available CAR T Therapies

Drugs	Tisagenlecleucel	Axicabtagene Ciloleucel
Brand	Kymriah	Yescarta
Mode of Action	Anti- CD19	Anti-CD19
Conditioning Therapy	Cyclophosphamide/Fludarabine	Cyclophosphamide/Fludarabine
FDA approved indications	B-cell ALL in children and young adults that is refractory or second or later relapse Greater than eighteen years old with aggressive B-cell non-Hodgkin lymphoma who failed greater than two lines of systemic therapy	Aggressive B-cell non-Hodgkin lymphoma greater than eighteen years old, who have failed at least two lines of systemic therapy

Clinical Trial Takeaways

- CAR-T therapy manufacturing and turnaround time needs improvement
- Therapies have high response rates compared to alternative regimens in these patient populations
- Significant adverse reactions seen

US Boxed Warning

- Applies to both Commercially available products
    - Cytokine release syndrome (CRS)
    - Neurological toxicities
    - Risk Evaluation and Mitigation Strategy (REMs) Program

CRS

- Excessive inflammatory cytokine release from high-level immune system activation
    - Immune system activation is necessary for efficacy
- Multiple cytokines involved but primarily IL-10, IL-6 and IFN-y with CAR T therapy
    - IL-6 thought to be a central mediator of toxicity in CRS

Therapies Associated with CRS

- Multiple different Immunotherapies
    - Monoclonal antibodies
        - Rituximab
        - Alemtuzumab
        - Blinatumomab
    - Adoptive cellular immunotherapy
    - Others

CRS Signs and Symptoms

- Collection of various inflammatory symptoms
    - Fevers
    - Myalgia
    - Hypotension
    - Pulmonary edema
    - Coagulopathy
    - Multi-organ failure

CRS Risk Factors

- High pre-infusion tumor burden
    - Greater than 50% blasts in the bone marrow
- Uncontrolled or accelerating tumor burden following lymphodepleting chemotherapy
- Active infections
- Active inflammatory processes

CRS Management

- Supportive care
    - Vasopressors, fluids, antipyretics, etc.
- Corticosteroids
    - Compromise efficacy of CAR T therapy
- Tocilizumab
    - Recombinant humanized monoclonal antibody
        - Substantially decreases cytokine production through IL-6 receptor antagonist
    - Dosing and administration
        - Weight < 30 kg:12 mg/kg/dose
        - Weight > 30 kg: 8 mg/kg/dose
        - Maximum dose: 800 mg/dose
        - Administered every 8 hours IV over 1 hour
            - Max of three doses in 24 hours, four doses total

Neurotoxicity

- May be severe or life-threatening
- Typically occurs within eight weeks of treatment
- Overall incidence: Any grade
    - Tisagenlecleucel: 65%
    - Axicabtagene ciloleucel: 87%

Other Common Adverse Effects

- Electrolyte abnormalities
  - Hypophosphatemia, hyponatremia, hypokalemia
- Gastrointestinal disturbances
  - Nausea/vomiting/diarrhea, decreased appetite
- Respiratory insufficiency
  - Hypoxia, cough, dyspnea
- Infection(s)
- Renal insufficiency
- Elevated total bilirubin, AST/ALT

REMS Program

- Required for both tisagenlecleucel and axicabtagene ciloleucel due to CRS and neurotoxicity risk
- Highlights
  - Certified healthcare facilities must have on-site, immediate access to tocilizumab with at least two doses available for administration within two hours after infusion start
- Required REMS participants: Providers who prescribe, dispense, or administer product

Administration/Preparation Pearls

- Must be REMS certified to prescribe, dispense, or administer product
- Product must be thawed prior to infusion
  - Tisagenlecleucel: Stable for 30 minutes at room temperature
  - Axicabtagene ciloleucel: Stable for three hours at room temperature
    - Room temperature: 20-25ºC
- Premedicate 30-60 minutes prior to infusion
  - Acetaminophen
  - Diphenhydramine or other H1 antihistamine
  - Do not use corticosteroids unless life threatening adverse reaction
- Follow universal precautions and local guidelines for safe handling and disposal

Logistical Questions

- Efficient largescale manufacturing processes
  - Patient specific products vs. commercialized product
- Billing
  - Drug vs. procedure
- Affordability
  - Healthcare system and patient

Treatment Costs

- Kymriah (tisagenlecleucel): $475,000
- Yescarta (axicabtagene ciloleucel): $373,000
- Stem cell transplant: Variable
    - Autologous: Median ~$100,000
    - Allogeneic: Median ~$200,000

Ongoing Studies

- Over 400 registered clinical trials currently investigating CAR-T therapies around the world
    - Clinicaltrials.gov
- Both oncologic and hematologic malignancies are represented in these studies

Summary

- CAR T therapy involves genetically modified autologous T lymphocytes while TIL therapy involves naturally occurring autologous lymphocytes
- Major adverse effects of CAR-T therapy include CRS and neurotoxicity
- Supportive care, tocilizumab, and/or corticosteroids may be used to manage CRS and neurotoxicity
- REMS training must be completed prior to prescribing, dispensing, or administering CAR-T therapy
- Uncertainty remains regarding how both hospitals and patients will afford these new therapies

Checkpoint Inhibitors: Mechanisms and Complications

FDA-Approved Checkpoint Inhibitors: Current as of January 10, 2019

- CTLA4 Antagonist: Ipilimumab
- PD1-inhibitor: Atezolizumab, cemiplimab-rwic, durvalumab, nivolumab, and pembrolizumab

Self-Reactive T-Cells are Deleted Early in T-cell Development

- T-cells develop in the thymus
- Self-reactive T-cells are destroyed during T-cell development
- T-cell repertoire only recognizes foreign non-self antigens
  - Infectious organisms and viruses
  - Pre-cancerous and malignant cells

Cancer Cells are Different

- Cancer cells are derived from “self” tissue but can be recognized as “non-self” by the immune system
- Cancer occurs via changes in the genetic code mutations which occasionally leads to changes in amino acid sequence of proteins
  - These “altered” peptides are displayed by tumor cells
  - Can be recognized by T-cells as non-self

Why do Immune Checkpoints Exist?

- Prevent complications from “unchecked” activation of the immune system
- Auto immune disease
  - Overzealous response to infection e.g., sepsis

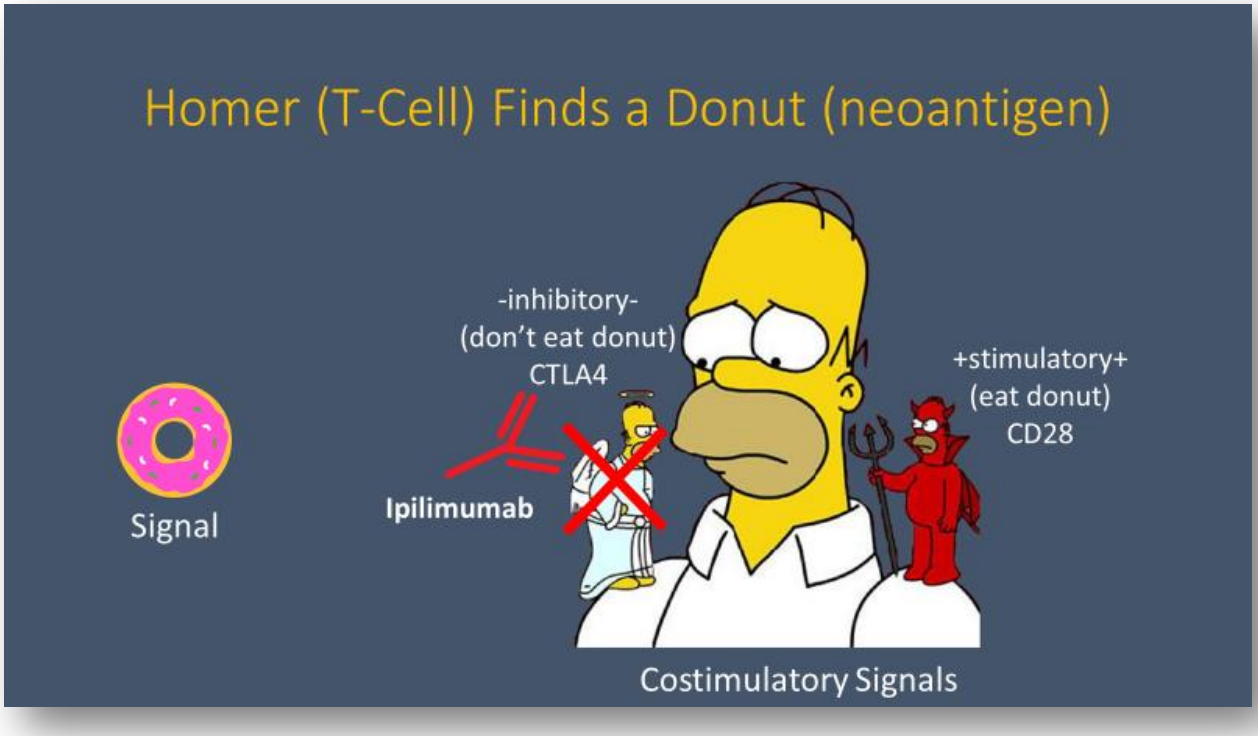
T-Cell Activation: A Multi-Step Process Embedded with Checks and Balances

- Step 1: Naïve T-cell binds neo-antigen on antigen-presenting cell
- Step 2: Costimulatory signaling
  - Stimulatory: CD28 or Inhibitory: CTLA4

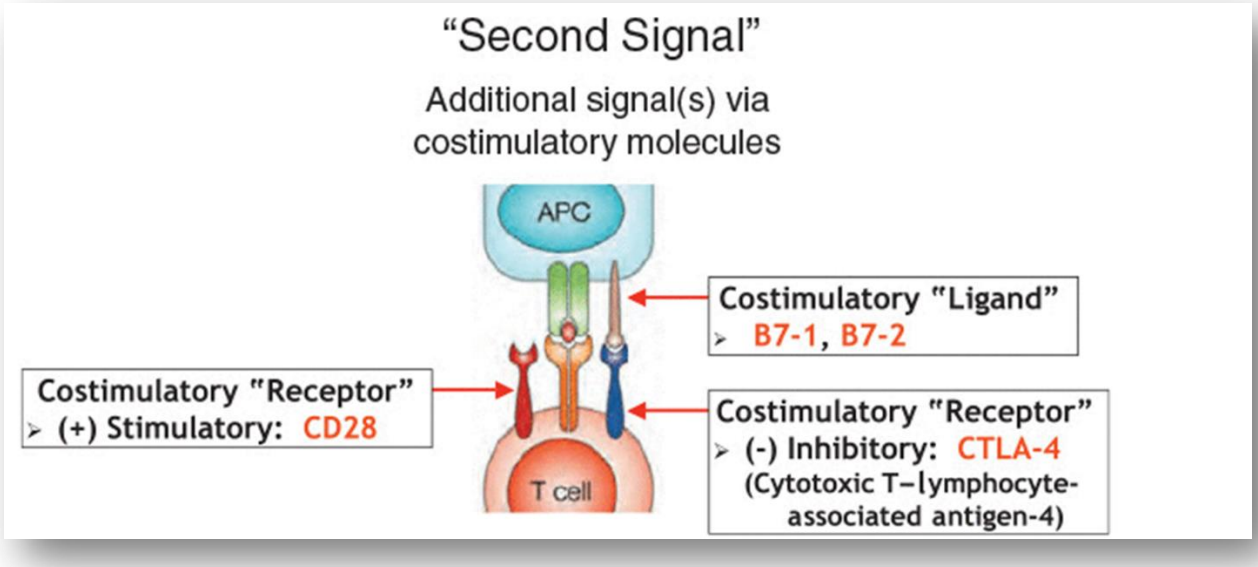
CTLA4 Receptor

- An inhibitory *costimulatory* receptor
  - Found on newly activated T-cells
- CTLA4 binds to B7 ligand expressed on antigen-presenting cells
- CTLA4 when bound to B7 inactivates the T-cell
  - Immune tolerance
  - Ipilimumab is a monoclonal antibody which inhibits CTLA4
    “Inhibits the inhibitor”: Result is more T-cell activation

Homer (T-Cell) Finds a Donut (Neoantigen)



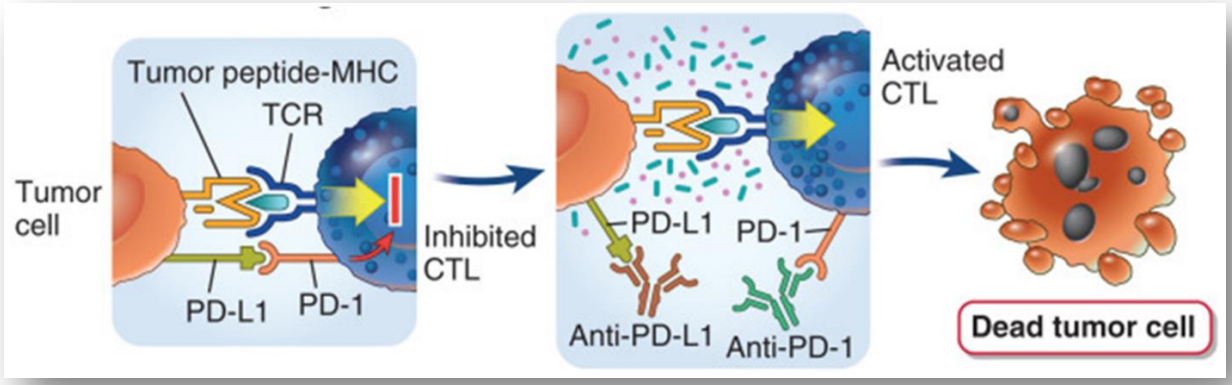
CTLA4 Receptor



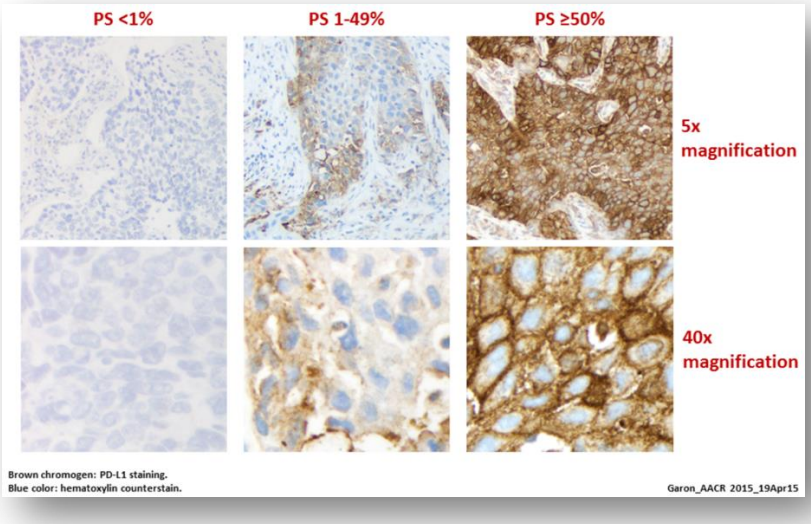
PD-1 and PDL-1 Checkpoint

- Expressed on activated T-cells
- Prevents excessive damage to self by activated T-cells
- PD-1 binds to PD-L1 and PD-L2 - suppresses T-cell effector function
- PD-L1 expressed by tumors to evade immune destruction
    - PD-1 inhibitors: Nivolumab, pembrolizumab, cemiplimab-rwic
    - PD-L1 inhibitors: Atezolizumab, avelumab, durvalumab
    - PD-L1 expression allows cancer cells to “disguise” themselves to avoid destruction

PD-L1 Checkpoint

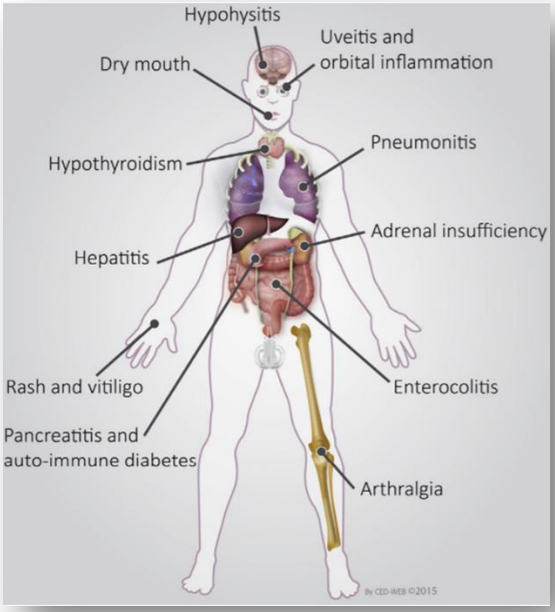


PD-L1 Expression in Tumor Cells May Predict Response to Checkpoint Inhibitors

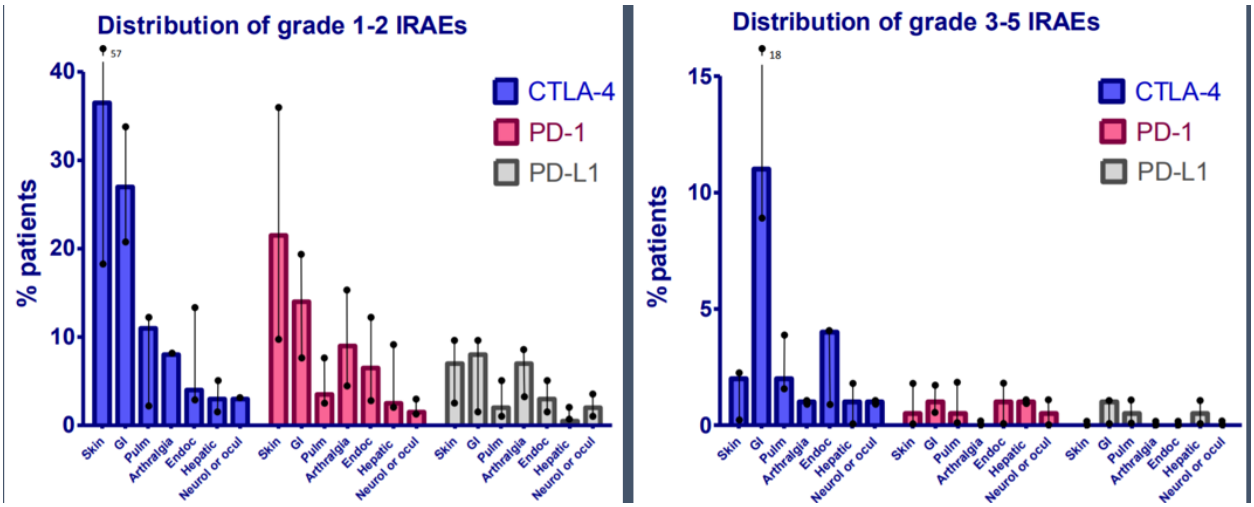


Spectrum of Immune-Related Adverse Events (iRAEs)

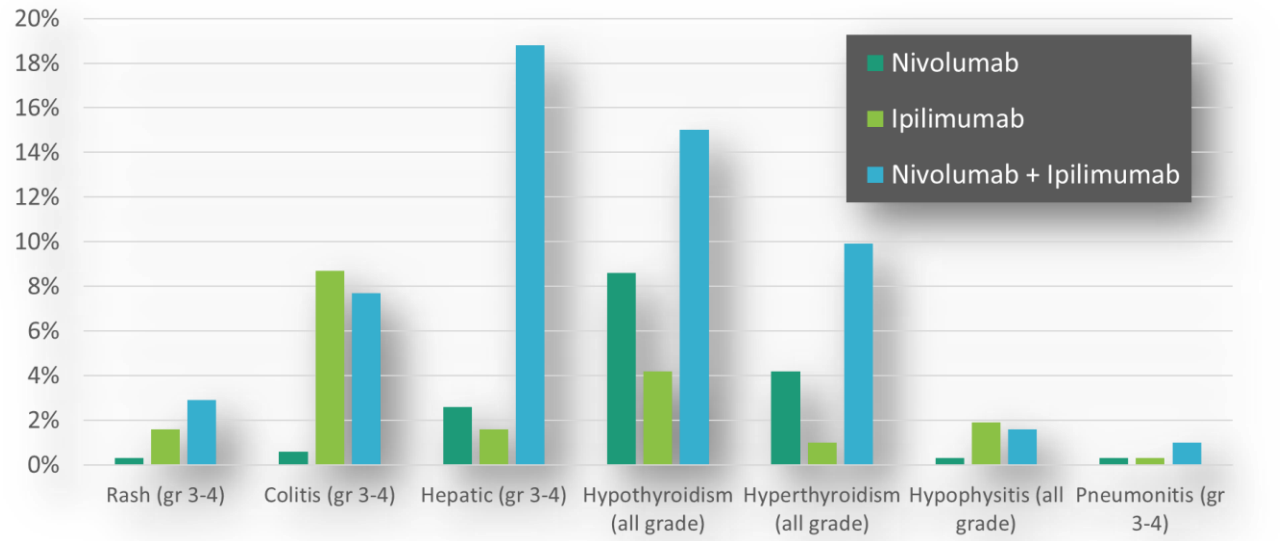
- Almost any tissue/organ is vulnerable
  - Gut
  - Skin
  - Lungs
  - Musculoskeletal
  - Nervous system
  - Pancreas
  - Kidneys
  - Eyes
  - Hematologic system
  - Endocrine system
    - Thyroid
    - Pituitary
    - Adrenal glands



Incidence of iRAEs



Immune-Related Adverse Events (iRAE)



Screening and Monitoring for iRAE

- Physical exam and review of systems prior to each dose
- Lab tests at baseline and prior to each dose
    - TSH: Reflex free T4
    - BUN/SCr
    - ALT/AST/bilirubin/alkaline phosphatase
    - Glucose
    - Sodium
    - ACTH: Consider for ipilimumab only

General Management Principles

- Refer to package insert and product website for details
- Accurate grading: NCI CTCAE
- Decide whether to hold/discontinue checkpoint inhibitor
- Consider corticosteroids
    - Additional immunosuppression if poor response
- Provide supportive care
    - GI prophylaxis
    - Glucose management
    - Bone health
    - Pneumocystis jiroveci pneumonia (PJP) prophylaxis

NCI CTCAE v5.0 Grading of iRAE: Overview

- Grade 1: Mild; asymptomatic, clinical/diagnostic observation only, no intervention indicated
- Grade 2: Moderate; minimal, local or noninvasive intervention indicated; limiting instrumental ADL*
    - * Preparing for meals, shopping for groceries or clothes, using telephone, managing money, etc.
- Grade 3: Severe or medically significant but not immediately life-threatening; hospitalization or prolongation of hospitalization indicated; disabling; limiting self-care ADL**
    - ** Bathing, dressing, feeding self, using restroom, taking medications, and mobile
- Grade 4: Life-threatening consequences; urgent intervention is indicated
- Grade 5: Death related to AE

General Management Criteria

- Grade 1: Monitor closely, continue checkpoint inhibitor cautiously
- Grade 2: Topical steroids, if applicable; Prednisone 0.5-1 mg/kg/day; Suspend checkpoint inhibitor; consider resuming when resolves to grade 1 or less
- Grade 3-4: IV corticosteroids (prednisone 1-2 mg/kg/day equivalent); Hospitalization may be indicated; Permanently discontinue checkpoint inhibitor in most cases; Consult specialist if indicated (e.g. dermatology, gastroenterology, endocrinology, pulmonology, etc.)

GI Adverse Effects: Enterocolitis

- Signs and/or symptoms
    - Diarrhea
    - Abdominal pain
    - Mucus or blood in stool
    - Fever
    - Peritoneal signs
    - Ileus
- Work-up
    - Blood tests: CBC, CMP, ESR, or CRP
    - Stool tests ova and/or parasites or clostridium difficile
    - CT scan
    - Consider colonoscopy with biopsy and CMV testing

Enterocolitis Management

- Consider GI consult and/or surgery consult for peritoneal signs
- Grade 1: < 4 stools/day above baseline
  - Monitor closely
  - Symptomatic treatment- loperamide and/or diphenoxylate/atropine
- Grade 2: 4-6 stools/day above baseline; duration > 5 days
  - Prednisone 1 mg/kg/day equivalent
- Grade 3-4: ≥ 7 stools/day above baseline
  - Consider hospitalization
  - IV corticosteroids: 1-2 mg/kg/day prednisone equivalent
  - If no response in 3-5 days, infliximab* 5 mg/kg IV q 2 weeks
    - * Off-label use of infliximab
      - Rule out latent TB prior to administering infliximab
      - Avoid infliximab in setting of sepsis or perforation

Hepatic Adverse Effects

- Signs and/or symptoms
  - Jaundice
  - Dark urine
  - Abnormal liver function tests
- Work-up
  - Rule out viral hepatitis
  - Consider CT or ultrasound to rule out liver metastases/obstruction if indicated
  - Consider liver biopsy

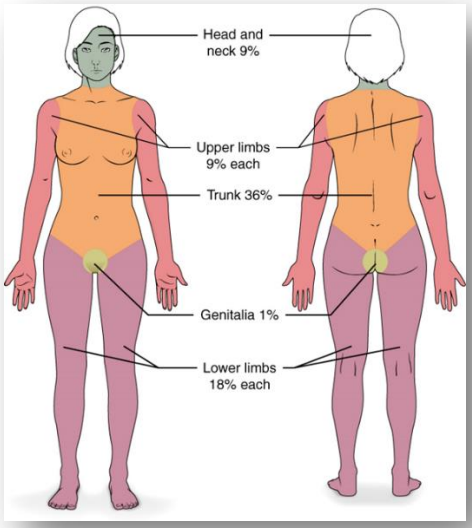
Hepatitis Management

- Consider hepatology consult
- Minimize hepatotoxic medications
- Corticosteroids 1-2 mg/kg/day prednisone equivalent
- If no response, add mycophenolate mofetil* or azathioprine*
  - * Off label medication

Dermatologic Adverse Effects

- Signs/symptoms
  - Pruritus
  - Rash
  - Vitiligo
  - Stevens-Johnson syndrome or toxic epidermal necrosis (very rare)
- Work-up
  - Skin biopsy
  - Consider clinical photography
  - Review medications

Rash Grading and Rule of 9's



Body Part	Estimated BSA
One entire arm	9%
Entire head	9%
Entire chest	9%
Entire abdomen	9%
Entire back	18%
One entire leg	18%
Groin	1%

NCI CTCAE v4.0	Grade 1	Grade 2	Grade 3
Rash maculo-popular	<10% BSA ± symptoms	10-30% BSA ± symptoms; limiting instrumental ADL	>30% BSA ± symptoms; limiting self-care ADL

Dermatologic Side Effect Management

- Grade 1-2: Topical steroids or antihistamines
- Grade 3-4: Topical steroids, antihistamines, dermatology consult, systemic steroids: 1-2 mg/kg/day prednisone equivalent, or possible consideration of hospitalization

Neurologic Adverse Effects

- Neurology consultation
- Work-up and treatment depends on syndrome
- Syndromes
  - Guillain-Barré syndrome
  - Myasthenia Gravis
  - Peripheral neuropathy
  - Autonomic neuropathy
  - Aseptic meningitis
  - Encephalitis
  - Transverse myelitis

Endocrine Adverse Effects

- Signs/Symptoms
  - Fatigue
  - Headache
  - Mental status changes
  - Abdominal pain
  - Unusual bowel habits
  - Hypotension
  - Primary hypothyroidism
  - Hyperthyroidism
  - Primary adrenal insufficiency
  - Hypophysitis: Pituitary inflammation
  - Autoimmune type 1 diabetes mellitus

Endocrine Adverse Effects

- Management
  - Consider referral to endocrinologist
  - Patient may be able to continue checkpoint inhibitor once stable on hormone replacement
  - Check TSH, free T4, ACTH, morning cortisol, glucose
  - Consider LH, FSH, testosterone, prolactin, and ACTH stimulation test
  - Consider MRI with pituitary cuts if concerned for hypophysitis
  - Hypophysitis: Consider short course of high dose steroids along with hormone replacement
  - Replacement hormones
    - Hypothyroidism: Levothyroxine
    - Adrenal insufficiency: Hydrocortisone
  - Recommendation of medical alert bracelet usage
  - Provide stress dose steroids as needed
- Adrenal crisis
  - Severe dehydration, hypotension, shock where hospitalization may be indicated
- Sex hormone deficiency: Testosterone, estrogen
- Type 1 diabetes: Insulin

Chemotherapy Protectants

Chemotherapy Protectants: Agents that are used to provide protection from the toxic effects of chemotherapy or radiation therapy

Protectant Drugs
- Leucovorin
- Dexrazoxane
- Amifostine
- Palifermin
- Mesna

Leucovorin
- Protectant for methotrexate (MTX)

MTX
- Mechanism of action
  - Works in the S phase of cellular division
  - Blocks the transformation of folic acid in the DNA/RNA division of the cell
- Uses in oncology
  - Acute lymphocytic leukemia (ALL)
  - Meningeal leukemia
  - Head and neck cancer
  - Osteosarcoma in high doses with leucovorin rescue
- Non-Cancer Uses
  - Rheumatoid arthritis
  - Psoriasis

Leucovorin
- Rescues bone marrow and mucosa from high dose MTX

Leucovorin Rescue
- Counteracts the mechanism of action for methotrexate.
- Actively competes with methotrexate for binding site
- Caution: Leucovorin increases the effects of 5FU

How Does Leucovorin Rescue Work?
- Leucovorin stops the action of MTX by blocking the transport pathways which allows folic acid to enter the cells
- Leucovorin can only rescue normal cells that have not already had lethal damage from the effects of MTX
- Treatment with leucovorin must be initiated within 24-36 hours of starting high dose MTX to be effective

_____
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Leucovorin Administration and MTX Levels

- Give an IV dose 24 hours after the start of MTX followed by oral doses every 6 hours until MTX levels are 0.05
- Dose adjustments can be made for delayed clearance
- BUN, creatinine, potassium, and urine output should be monitored together to assess for kidney function

Times to Draw MTX Levels

- For a 4-hour IV bolus infusion of MTX the MTX level should be drawn at 24 hours after the start of the infusion followed by daily morning labs.
- For a 24-hour infusion of MTX the first MTX level should be drawn 24 hours after the completion of the bag, followed by daily morning lab

Zinecard (dexrazoxane)

- Protectant for cardiomyopathy with doxorubicin
- Used to reduce the incidence and severity of cardiomyopathy associated with doxorubicin administration
- Indicated when cumulative dose of doxorubicin ≥ 300 mg/m2
- Handle with chemo precautions
- May increase bone marrow depression
- May decrease tumor response rates if additional anthracyclines are administered

Administration

- Slow IV push or rapid IV infusion
- Dexrazoxane must be IV infusion Not IV push bolus
- Generic formulation IV push or IV infusion
- Administer dexrazoxane first; then doxorubicin
- Administer doxorubicin over 15 minutes within 30 minutes after beginning the infusion of dexrazoxane

Potential Toxicities/Side Effects

- Dexrazoxane may increase the bone marrow suppression caused by doxorubicin
- May cause elevation in liver and renal function studies
- Pain at Injection site

Ethyol (amifostine)

- Protects from effects of cisplatin

Chemoprotectant

- Decreases cumulative nephrotoxicity from cisplatin
    - Detoxifies active metabolites of cisplatin
- May be considered for the reduction of grade 3 and 4 neutropenia associated with chemotherapy and/or in place of dose reduction or use of growth factor

Radiation

- Protects parotid glands and anus/rectum if in the field
- Prevents xerostomia and prostatitis

Administration

- Chemoprotectant
    - Administered over 15 minutes
    - Give 30 minutes prior to cisplatin
- Radio protectant
    - Xerostomia
        - Administered over 3 minutes
        - Give 15–30 minutes prior to the radiation treatment
            - Prostatitis
    - IV once daily prior to radiation therapy

Side Effects

- Hypotension
    - Most common side effect, more common at chemoprotectant dose
    - Stop anti-hypertensives 24 hours prior to dose
    - Treat symptoms with IV fluids and Trendelenburg's position
    - Refer to dosing guidelines for patients experiencing hypotension
- Nausea
    - Pre-medicate with serotonin antagonist and decadron

Mesna

- Protectant from Ifex (ifosfamide)
- Bladder protectant given with ifosfamide and cyclophosphamide
- Acrolein: Hepatic metabolite of both drugs that causes acute bladder irritation leading to hemorrhagic cystitis
- Always administer mesna when treating with ifosfamide
- Use mesna with high dose cyclophosphamide regimens used for stem cell transplant

Mesna Administration

- Can be given IV or PO
- Can be given as IV bolus or continuous infusion as indicated by dose of ifosfamide given

Common Side Effects

- Can cause false positive result on urinalysis for ketones
- May cause mild nausea/vomiting
- May cause mild diarrhea

Palifermin

- Protectant for mucositis
- Mucositis following chemotherapy
- Patients requiring autologous hematopoietic stem cell transplant
- Prophylaxis

Administration

- Total of 6 doses is given
- 60 mcg/kg/day IV bolus
    - Three consecutive days before myelotoxic therapy
        - Third dose should be given 24 to 48 hours prior to starting myelotoxic therapy
    - Three consecutive days after myelotoxic therapy
        - First doses should be administered after, but on the same day of, hematopoietic stem cell infusion and at least seven days after most recent dose of palifermin

Common Side Effects

- Edema
- Erythema
- Pruritus
- Arthralgia
- Dysesthesia
- Fever
- Pain

Adverse Events

- Gastrointestinal: High lipase level in serum

Special Considerations

- Potential for tumor growth in nonhematologic malignancies
- Nursing mothers should either discontinue nursing or discontinue drug

Nursing Implications

- Teach patient to report any changes in skin
- Teach patient signs and symptoms of infection
- Encourage patient to report any changes in tongue or taste
- Teach patient systematic oral cleansing after meals and at bedtime
- Assess patient baseline pain

_____
_____
_____
_____
_____

Error Prevention

What are Medical Errors

- Unintended act or act that does not achieve intended outcomes
- Failure of a planned action to be completed as intended
- Use of the wrong plan to achieve an aim
- Deviation from the planned process
- May or may not cause patient harm

Examples of Medical Errors

A pharmacist entering chemotherapy for future appointment noted that there was a 5 cm discrepancy of height from previous doses. All previous chemotherapy doses were calculated based on a height of 145 cm, and the upcoming dose was calculated based on a height of 150 cm. This resulted in an increase of dose. The pharmacist confirmed with ordering office that the patient's height was 150 cm and that the previous height was incorrect. All previous doses were given at the lower dose.

An order was sent to an infusion center from the physician's office. Order written as Herceptin [trastuzumab] 2 mg/kg (184 mg) in 250 mL NS IV over 30 minutes cycle 1 day 8 and day 15 Q 21 days. The order was interpreted as "administer Q 21 days" when intended dosing was day 1, day 8, and day 15. The patient missed doses due day 8 and day 15. The oncologist was notified, and the patient was informed. The oncologist altered schedule for remaining chemo doses.

Annual Impact of Medical Errors: Causes of Death in the United States in 2018

1. Heart disease: 611,000
2. Cancer: 585,000
3. Medical errors: 251,000
4. Respiratory disease: 149,000

What Puts a Patient at Risk?

- At risk providers
- Multi-tasking
- Inattention
- Distraction
- Lack of interest
- Poor preparation
- Cognitive bias

At Risk Patients: Oncology Patients

- Cancer care is complex and hazardous for patients and providers
- Requires extra caution to maintain safety and prevent errors
- Patients with cancer cannot tolerate mistakes

At Risk Patients: Outpatient Oncology

- Care is distributed across different clinicians and departments
- Clinicians have limited time with patients
- Patients spend a majority of their time during cancer care away from the treatment center
- Patients lack professional expertise in oncology

At Risk Patients: Patients Receiving Chemotherapy

- Drugs with narrow therapeutic index
- Drugs are toxic, even at therapeutic levels
- Complex drug regimens
- Multiple protocols
- Numerous steps to administration

Errors and the Multidisciplinary Team

- Multidisciplinary teams are a necessary component of oncology care
- Team members may be in different geographical locations, only involved in a patient's care for a short time, or may be focused on a single aspect of the cancer care plan
    - Likelihood of errors increase with the number of physicians involved in care
- Effective communication and teamwork are critical in oncology

Prevention: Safe Practice Recommendations

- All staff involved in the management of cancer and its therapy must have the relevant knowledge and skills and be competent to perform the tasks
- Appropriate staffing numbers and skill mix for all disciplines should be in place to ensure that safe practices can be followed
- All staff should have access to information applicable to the patient and the treatment including diagnosis, medical history, pathology results and the treatment plan

Safe Practice Recommendations: Prescribing

- All chemotherapy and targeted therapy should be prescribed on the basis of a documented, referenced protocol and a treatment plan documented for all patients
    - Protocols should outline all therapies, dosages, and scheduling relevant to the treatment
- Audits should be completed to identify error prone areas or processes
- Medication orders for chemotherapy and targeted therapy should be clear, consistent and unambiguous, and include all supportive therapy associated with the protocol
    - Computer generated or pre-printed forms are preferable to handwritten orders
- All treatment should be clinically verified by a pharmacist prior to dispensing
- Oral chemotherapy should be subject to the same procedures for prescribing and dispensing as parenteral therapy and labelled with clear instructions to minimize potential administration errors by the patient

Safe Practice Recommendations: Administration

- Know what drugs are being administered
    - Action, use, dose, route, elimination, side effects, contraindications, and nursing considerations
- Understand the patient's drug history, including allergies
- Be aware of potential drug-drug and drug-food interactions
- Follow policies and procedures in place
    - UPMC Systemwide Policy HS-ONC0005
- Educate the patient and caregiver
- Speak up

Policies and Procedures: UPMC Systemwide Policy HS-ONC0005

- Step 1 – Verification by two antineoplastic drug qualified nurses
    - Informed consent
    - Allergies
    - Height and weight
    - Labs
    - Regimen
    - Premeds/fluids
    - BSA/dose
- Step 2: Verification by an antineoplastic drug qualified RN and one other professional RN
    - Drug compared to the MD order
    - Patient name, FIN, and/or MRN
    - Date to be administered
    - Day of treatment
    - Correct drug(s)
    - Correct dose(s)
    - Expiration date and time
    - Appearance and physical integrity of the drug
    - Route and rate of administration

Patient Education

- Patients play in important role in their own care
- Include the patient and the family or caregiver
- Written and oral instruction
- Educate on medications, side effects, when and how to contact providers, and when to seek emergency care

Rule-Based Patient Education

- “Your infusion pump will be set to 200ml per hour, meaning that this infusion will take one hour to complete.”
- “You will receive this blue tablet before each infusion as a premedication.”
- “Now that we have confirmed your name and date of birth, let’s read your chemotherapy label together.”
- “The IV medication you will be receiving is red.”

Speak Up

- "I need clarity”
    - Alerts all team members of an issue
    - All activity should stop until the issue is resolved
- Report errors and near misses in RiskMaster
    - May report anonymously

Error Reporting

- Critical step to reducing errors
- Allows learning and the development of processes to prevent similar events from occurring in the future
- Why don’t errors get reported?
    - Fear
    - Embarrassment
    - Don’t understand the importance of reporting
    - Concerns of liability and confidentiality

A Just Culture

- At UPMC, A Just Culture is used to respond to and analyze error
    - Empowers staff to voice patient safety concerns
    - Provides consistent guidelines for dealing with mistakes and near misses
    - Ensures providers involved are treated with dignity, respect, and consistency
    - Assures leaders act in a fair and consistent manner
    - Creates system accountability
    - Fosters a culture of learning and safety

Establishing a Culture of Safety

- Acknowledgment of the high-risk nature of an organization’s activities and the determination to achieve consistently safe operations
- A blame-free environment where individuals are able to report errors or near misses without fear of reprimand or punishment
- Encouragement of collaboration across ranks and disciplines to seek solutions to patient safety problems
- Organizational commitment of resources to address safety concerns

Extravasation of Vesicant/ Irritant Chemotherapeutic Agents

Anecdotal and Controversial Subject

- Based on animal data and case reports
- Toxic local tissue reactions account for 0.1-6% of all adverse effects of antineoplastic agents despite careful technique

Defining Terms

Extravasation	Inadvertent escape of a medication/fluid from a vein into surrounding tissue
Infiltration	Agents that are capable of producing venous pain at the site and along the vein with or without an inflammatory reaction
Vesicant	Inadvertent escape of a vesicant from a vein into surrounding tissue
Irritant	Agents that do not cause tissue necrosis or irritation when infiltration occurs
Nonirritant/Nonvesicant	Agents that are capable of forming a blister or tissue necrosis when extravasated

Vesicants

- Platinol
- Dactinomycin
- Daunomycin
- Doxorubicin
- Epirubicin
- Idarubicin
- Mechlorethamine HCL
- Etoposide
- Paclitaxel
- Mitomycin
- Vinblastine
- Vincristine
- Vindesine
- Vinorelbine
- Mitoxantrone

- The process of tissue destruction caused by leakage of vesicants into the tissue is by nature indolent and progressive

Irritants

- Carboplatin
- Carmustine
- Cisplatin
- Dacarbazine
- Docetaxel
- Etoposide
- Melphalan
- Arsenic
- Bortezomib
- 5-fluorouracil
- Gemcitabine
- Daunorubicin liposomal
- Doxorubicin liposomal
- Paclitaxel
- Streptozocin
- Irinotecan
- Ixabepilone
- Thioplex

Categories of Extravasation of Chemotherapeutic Agents

- Those that _____ not bind to tissue nucleic acids: Cause immediate tissue damage but are quickly metabolized or inactivated
- Those that _____bind to tissue nucleic acids: Cause immediate injury, lodge in the tissue, and bind to DNA

Factors Related to the Degree of Injury

- _____
- Amount
- _____ of exposure
- Affected tissues

Risk Factors

- Debilitation
- Previous treatment: Multiple _____
- Elderly: Friable veins, history of circulatory disease
- Small peripheral veins
- Venous spasm due to changes in body temperature, hypertension and psychological factors
- Previously _____ site: Radiation recall
- Extremity edema: Due to axillary surgery
- Peripheral neuropathy due to disease or treatment: May blunt pain perception
- Vesicant potential of the drug
- _____ of the drug
- Amount of drug infiltrated
- Duration of tissue exposure
- Inability to communicate discomfort such as very young or pre-medicated patients

Signs and Symptoms of a Peripheral Extravasation

- _____ of blood return, however, may be present
- Swelling
- Erythema, inflammation
- Leaking at catheter entrance site
- _____, burning, or stinging

_____
_____
_____
_____
_____

Chemical Phlebitis

- Heralded by burning sensation along the course of the involved vein, followed by a streak of erythema along the course of the vein
- Commonly associated with anthracyclines, nitrogen mustard, nitrosureas
- Treat with warm, moist compress and avoid repeated venipuncture

Vessel Irritation

- Aching and _____ along the vein
- Reddish or dark discoloration along the length of the vein

Flare Reaction

- Adriamycin, daunomycin, nitrogen mustard
- Occurs in _____% of cases
- Transient: 30 minutes
- Erythematous streak along the course of the vein
- Pruritis, urticaria

Signs and Symptoms of Extravasation in a Venous Access Device (VAD)

- Assess chest wall for _____, leaking at catheter exit site: If external catheter
- May have referred pain/burning to shoulder, neck, or arm
- May have edema/erythema to port pocket
- Note fluttering or flopping in chest

Causes of Drug Extravasation in Implanted Ports

- Needle _____
- Thrombosis within catheter tip within subclavian vein: Back-tracking of drug around catheter and into skin pocket
- Separation of catheter from port, or catheter fracture, and embolization onto the heart

Risk Factors for VAD Extravasation

- High-risk location of port: Groin, abdomen
- Improperly secured port within pocket: “Floats”
- Damaged catheter
- Improper needle _____ for septum depth
- Improper _____ of needle in septum
- Obesity
- Vigorous patient activity: Heavy lifting, sports
- Twiddlers’ syndrome
- Vigorous coughing
- Inability to communicate discomfort: Very young or pre-medicated patients

_____
_____
_____
_____
_____

Extravasation Management

- Requires immediate recognition and emergency treatment
    - Peripheral extravasation
        - Immediately _____ infusion
        - Leave IV catheter in place
        - Remove IV tubing
        - Aspirate residual drug/blood
        - _____ area in cm/in and mark area
        - Estimate volume extravasated
        - Photograph the site
        - Remove IV
        - Cover with light dressing
        - Inject _____ antidote (if any) by standing/MD order
            - Make as few punctures as possible and reposition needle under skin to infiltrate the entire area of infiltration
        - Apply warm or cold compresses as indicated
            - Heat
                - Vincristine, vinblastine, vincristine liposomal, vinorelbine and etoposide
                - Rationale: Vasodilation facilitates absorption
                - Use immediately for 30-60 minutes at a minimum, then on for 15-20 minutes QID for 48-72 hours
            - Cold
                - Oxaliplatin, cisplatin, adriamycin, epirubicin, dactinomycin, daunorubicin, idarubicin, and mechlorethamine
                - Rationale: Vasoconstriction localizes extent of absorption
                - Use – immediately for 30-60 minutes at a minimum, then on for 15-20 minutes QID for 48-72 hours
        - Elevate extremity
    - VAD Extravasation
        - Follow steps of peripheral extravasation
        - Treat subcutaneous tissue if indicated
        - Radiographic study: Chest x-ray to rule out mechanical obstruction and check placement catheter dye study/venogram diagnoses clot formation or defect

Antidotes

- Animal models such as pig, mouse, rat, or dog
  - Extrapolation from animals to humans is difficult
- Unproven therapies
  - Corticosteroids
  - Sodium bicarbonate
  - Dimethyl sulfoxide (DMSO)
  - Propranolol and isoproterenol
- Sodium thiosulfate
  - Used subcutaneous with cold compresses for mechlorethamine, Platinol (cisplatin), and Eloxatin (oxaliplatin)
- Hyaluronidase
  - Used subcutaneous with warm compresses for etoposide for a large volume (> 20 mg/mL) or high concentration infiltrate > 0.5 mg/mL and vinca alkaloids: Vincristine, vinblastine and vinorelbine

Antitumor Antibiotics

- Most common extravasation is _____, but daunorubicin, epirubicin, and idarubicin also common
  - Cold compresses
- No antidote until the FDA approved Totect in September 2007

Totect (dexrazoxane)

- A new agent for _____ extravasation only
  - Doxorubicin, daunorubicin, epirubicin, and idarubicin
- Administration
  - Given IV daily for three days
  - First infusion within six hours of event
  - BSA is used to calculate the dose
    - Maximum dose is 2000 mg
  - _____ drug: Safe handling with gloves and gown
  - Day one: 1000 mg/m^2
  - Day two: 1000 mg/m^2
  - Day three: 500 mg/m^2
- Side effects
  - _____
  - _____
  - Fever
  - Infusion site reactions: Pain, phlebitis
  - Nausea/vomiting: Use premeds
  - Reversible increase in liver function tests (LFTs)

_____
_____
_____
_____
_____

Taxanes

- Controversial
- Oncology Nursing Society (ONS) recommends cold compresses and UPMC policy recommends cold compresses if patient complains of pain

Charting

- _____ and _____
- Number of insertions attempts and location
- Needle size and type or type of VAD
- Anatomic vein
- Name of _____, total dose ordered, and dilution in mg/mL
- Approximate amount of agent extravasated and solution
- Sequence of administration
- Nursing management of extravasation
- Photo documentation
- Subjective patient description of discomfort and/or sensation
- Appearance of site
    - Note size in cm/in
- Physician notification
- Follow-up measures
- Incident report: Per institutional policy

Plastic Surgery Consult

- Critical time for plastic surgery referral: Severe pain, early necrosis, blistering
- Debridement and/or skin graft

Prevention

- Develop institutional guidelines
- Credentialing program for staff
- Consider _____ early in treatment
- Select preferred site
- Avoid vein where there was a recent venipuncture
- Start IV catheterization attempts distally
- Secure needle but allow visibility of site: Assess _____ _____ per policy
- Monitor patient after ambulation
- Avoid extremity with impaired _____
- Evaluating a VAD for use
    - 100 cc fluid bolus if suspicious
    - Read surgical/radiology reports
    - Ensure dressing over implanted port is secure

_____
_____
_____
_____
_____

- Teach patient about risk
    - Report to nurse any discomfort or unusual sensations during administration
    - Observe and report any chest wall swelling or exit site leak if VAD
    - If extravasation does occur, explain what happened, what will be done, and the importance of follow up
- Insure consistent patient follow-up

Cost Considerations in Extravasation-Related Injuries

- Increased length of stay
- Consultations with specialists: Plastics, neurologist
- Debridement or grafting
- Higher drug costs: Antidotes, analgesics, antibiotics
- Follow-up care
- Physical therapy
- Additional medical supplies
- Lost wages

Litigation Involving Extravasation Considerations

- When a malpractice suit is brought against a nurse after the extravasation of a vesicant agent, the following questions are raised
    - Formal policy/guidelines followed
    - Drug administered in accordance with MD orders
    - Stopped infusion immediately if complaint of pain or burning
    - Appropriate action taken to manage extravasation
    - Physician informed promptly
    - Accurate description in medical record

Fallacy: The Less You Document the Less You Implicate Yourself

- Use FACT to chart
    - F = factual
    - A = accurate
    - C = complete
    - T = timely

Hematopoietic Growth Factors

What are growth factors?

- Hematopoietic growth factors are glycoproteins
- Play a role in proliferation, differentiation, and survival of primitive hematopoietic stem and progenitor cells as well as in functional activation of some mature cells

Targeted Patient Population

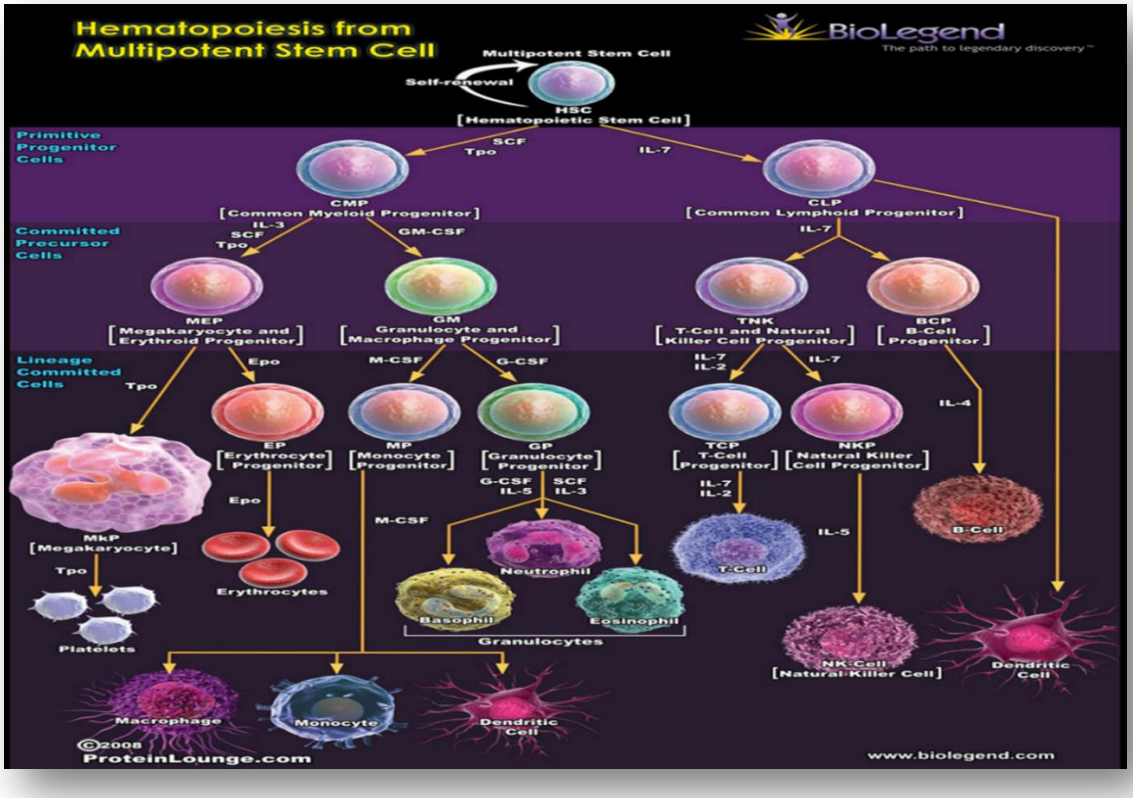
- Solid and hematological malignancies
- Treated with myelosuppressive therapy
- Used as primary treatment
    - Hairy cell leukemia
- Inherited bone marrow failure syndromes
    - Fanconi anemia
- Stem cell transplant/mobilization/graft failure
    - Autologous, allogeneic, donors
- HIV
- Chronic anemia
    - Chronic renal failure, aplastic anemia, sickle cell anemia

Significance for Today's Patients

- Cost-effective
    - Decrease admissions, testing, antibiotics resistance, transfusion needs
- Improve patient outcomes
    - Decrease neutropenia and risk of infection
    - Decrease thrombocytopenia and risk of bleeding
    - Decrease anemia and fatigue/activity intolerance
- Improved quality of life- Priceless

Types of Growth Factors

- Single lineage factors
- Granulocyte colony-stimulating factors (G-CSF, pegfilgrastim)
- Erythropoietin (r-HuEPO)
- Platelet growth factors
- Stem cell factor (SCF)
- Multi-lineage factors
    - Granulocyte-macrophage colony-stimulating factor (GM-CSF)



Myeloid Cells

Type	Count (x10^9/L)	Life Span
Neutrophils	1.8-7.7	10-13 days
Eosinophils	0.035-0.35	> 11 days
Basophils	0.00-0.11	16-21 days
Erythrocytes	4,000-6,000	120 days
Platelets	150-400	5-9 days
Monocytes, Macrophages, Dendritic cells	0.5-1.0	Months to years in tissues

Functions of Specific Leukocytes

- Eosinophil: Protect against infections and foreign substances by phagocytosis
- Basophil: Involved in inflammatory reactions, especially related to allergies and asthma
- Monocyte: Destroys bacteria and cellular debris
- Macrophage: Recognizes foreign proteins and microorganisms and responds by ingestion and phagocytosis

Myelosuppression

  - Suppression of bone marrow activity resulting in neutropenia, anemia, and thrombocytopenia
- Results from
  - Chemotherapy
  - Radiation therapy
  - Biotherapy
- Most common dose-limiting toxicity

Neutrophils Attack

- First responders
- Attack by ingesting and destroying foreign invaders

Neutropenia

- Decreased number of circulating neutrophils
  - Increased risk of infection
  - Increased severity of infection
  - Impaired immune response can quickly lead to sepsis
- Typical signs of inflammation and infection are absent
- Infection: Most common cause of death in a patient with cancer

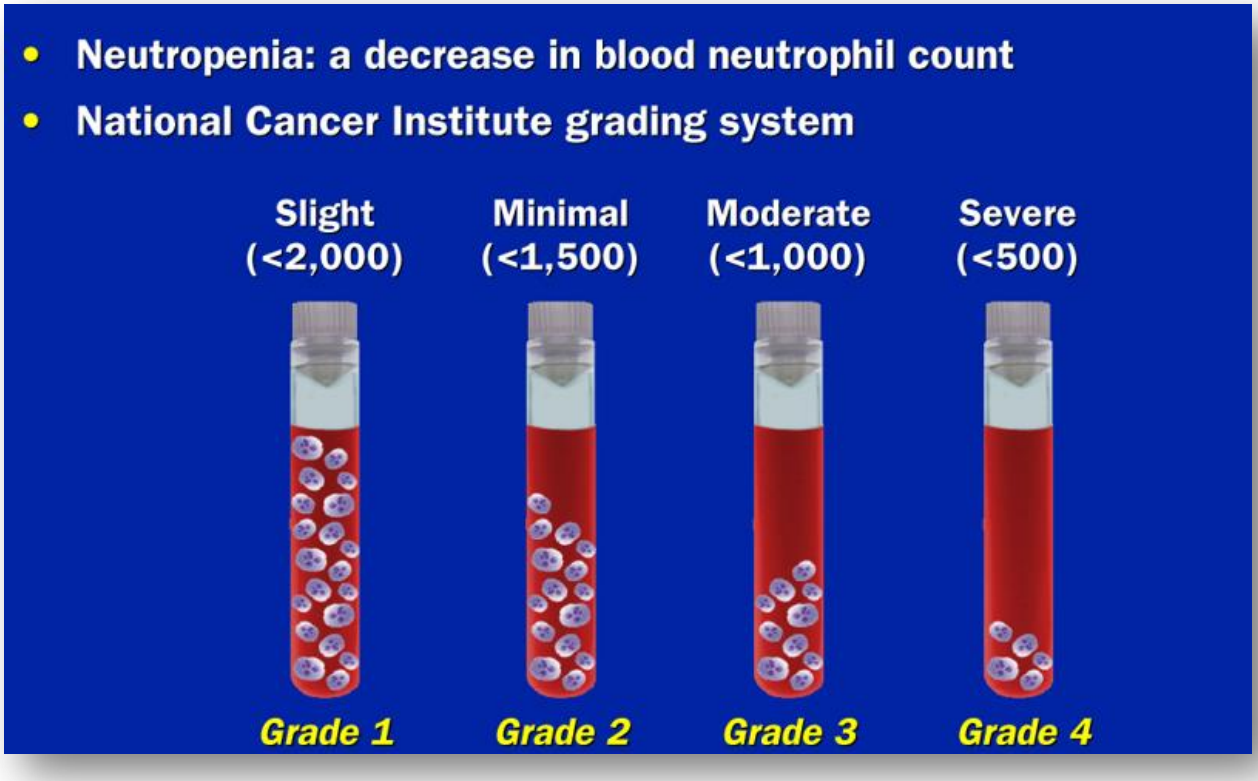
Neutropenia Risk Factors

- Myelosuppressive chemotherapy regimen
  - Prior cycles of myelosuppressive regimens
  - History of prolonged neutropenia or febrile neutropenia
  - Bone marrow involvement and/or hematological malignancies
  - Age ≥ 65 years
  - Malnutrition
  - Low neutrophil count when starting treatment
  - Prior extensive radiation therapy
  - Severity is determined by calculating the absolute neutrophil count (ANC)

Caculating the ANC

$$ANC = \frac{(\%Segs + \%Bands)}{100} \times WBC$$

Interpreting the ANC and Neutropenia



G-CSFs

- Improve growth of granulocyte colonies by affecting production and differentiation of neutrophil progenitor and precursor cells
    - Increase phagocytic activity
    - Increase antimicrobial killing
    - Enhance anti-body dependent cell-mediated cytotoxicity
- Given to help decrease length and/or severity of neutropenia

Neupogen (filgrastim)

- Indicated for cancer patients receiving myelosuppressive therapy
- Patients receiving induction/consolidation for AML
- Decrease risk/duration of neutropenia in post-peripheral blood stem cell transplantation (PBSCT)
- Mobilization for PBSCT
- 1.5-10mcg/kg/day depending on indication
- Do not give within 24hrs of chemotherapy administration

Neulasta (pegfilgrastim)

- Given to help decrease the rate/risk of infection caused by chemotherapy for non-myeloid malignancies
- 6mg subcutaneous injection (SQ) once a cycle
- Do not overlap chemotherapy within 14days before or 24hrs after administration

Side Effects of G-CSFs

- Allergic reactions: Wheezing, rash, dyspnea, urticaria
- Peripheral edema
- Bone pain
- Fever: < 100.4F
- Myalgia
- Headache
- Injection site reaction
- Sickle cell disease exacerbation
- Adult respiratory distress syndrome (ARDS)
- Splenic rupture

Patient Care Implications

- Assess for pain
- Assess respiratory status
- Assess abdominal area
- Monitor Complete blood count (CBC): Increased neutrophils
    - Contraindicated in patients known hypersensitivity to E. coli-derived products
- Patient education on Neutropenic Precautions
    - Encourage adherence to care regimen

GM-CSFs

- Multi-lineage factor
- Receptors that exist on myeloid lines
    - Stimulates proliferation and differentiation: Neutrophil and macrophage lines
- Enhances functional activities of neutrophils and monocytes/macrophages
    - Enhanced activity in killing bacterial/fungal organisms

Leukine (sargramostim)

- Approved by FDA
    - After induction chemotherapy in older patients with AML (< 5%blasts)
    - Mobilization of stem cells
    - Myeloid recovery after Auto SCT
    - Graft failure or engraftment delay
    - 250mcg/m2/day SQ

Side Effects of GM-CSFs

- Allergic reactions (wheezing, rash, dyspnea, urticaria)
- Bone pain
- Skin reaction
- Fever
- Flu-like symptoms
- Headache
- Arthralgias/myalgias
- Pericardial effusions
- Capillary leak syndrome
- Third spacing

Patient Care Implications

- Same as G-CSFs
- Monitor CBC, pain, etc.
- Educate regarding first dose reactions
    - Symptom support is available
    - Not a reoccurring event

Red Blood Cells

- Largest proportion of the blood cells
- Mature red blood cell count (RBC) have a biconcave shape
    - Allows them to change shape without breaking to fit through tiny, winding capillaries
    - Facilitates absorption and release of oxygen molecules
- Carry oxygen to all parts of the body
- Production is regulated by the kidneys

Anemia

- Not a specific disease, but manifestations of a pathological process
- Characterized by
    - Decrease in number of erythrocytes
    - Decrease in amount of hemoglobin
    - Decrease in the volume of packed red blood cells (Hematocrit)

Classification of Anemia: National Cancer Institute (NCI) Scale

Grade (severity)	Hgb (g/dl)
0 (None)	Men: 14-18 Women: 12-16
1 (mild)	10 to within normal limits
2 (moderate)	8-10
3 (serious/severe)	6.5-7.9
4 (life-threatening)	< 6.5

Erythropoietin (EPO)

- Naturally produced by kidneys and affects specific myeloid progenitor cells and erythrocytes
- Regulated by feedback mechanism involving perception of decreased oxygen tension in tissue
    - Production and secretion is inversely affected by oxygen-carrying capacity of circulating red blood cells
- Unlike other growth factors
    - Exclusively secreted outside bone marrow microenvironment by liver and kidneys
    - Acts in later stage of blood cell development
    - Binding of stimulant and forming units: Erythropoiesis

Erythropoietin Stimulating Agents (ESAs)

- Recombinant Erythropoietin (r-HuEPO): Synthetic version of EPO
    - Given to help improve red blood cell production to decrease effects of anemia
- Originally intended for renal failure patients, heavily used in past for any anemia in oncology patients
- Recently studies show risk for inferior tumor control and shortened survival times
- Not indicated patients receiving chemotherapy anticipating cure patients with anemia not associated with chemotherapy, Hgb <10g/dL or >12g/dL

Epogen and Procrit (erythropoietin alfa)

- Chemotherapy-induced anemia with non-myeloid malignancies
- Zidovudine therapy in HIV pts
- Chronic renal failure in end stage renal disease
- Either with or without dialysis
- 50-150 unit/kg 3x/wk or 40,000 units as single dose every week
    - If Hct does not increase by week 8, increase dose by 25-50units/kg until 300units/kg 3x/wk max dose
    - If Hct does not rise by 5-6% in 8wks, increase weekly dose by 60,000 units SQ every week
    - If no response, increase to 80,000 units SQ maximum
- If Hct levels > 40%- Hold
    - Once Hct 36%, restart at 75% original dose

Aranesp (darbepoetin alfa)
Indication

- Chemotherapy-induced anemia with non-myeloid malignancies
- Chronic renal failure or end stage renal disease
    - Without dialysis
- 2.25mcg/kg SQ once a week: Starting dose
    - If < 1.0g/dL Hgb after 6wks, increase dose to 4.5mcg/kg
    - If >1.0g/dL increase in two weeks or Hgb>12g/dL, decrease dose by 25%
- If Hgb >13g/dL: Hold
    - Once Hgb 12mcg/dL, restart at 75% original dose

Side Effects of ESAs

- Hypertension (HTN)
- Thrombotic events
- Seizures
- Headaches
- Skin rashes, urticaria, transient rash at injection site
- Fatigue
- Edema
- Nausea/vomiting, diarrhea, dehydration
- Fever
- Dyspnea

Patient Care Implications

- Balance benefits vs. risks
- Raise hematocrit slowly aiming for 30-35% to avoid HTN
    - Monitor CBC increased hemoglobulin and hematocrit weekly
- Consider status of iron stores
    - Check iron studies prior and during treatment course
    - Addition of iron supplementation meet demand of increasing erythrocyte numbers
- Assess respiratory status: Edema

Patient education

- Encourage adherence to care regimen
- Encourage adherence to iron supplementation, if applicable
- Encourage frequent rests

Platelets

- Small, irregularly shaped, colorless cell fragments
- 2/3 in circulation and 1/3 stored in spleen
- Play significant role in clot formation and tissue repair/regeneration
    - Sticky
    - Like to aggregate

Risk Factors for Thrombocytopenia

- Myelosuppressive chemotherapy
- Radiation therapy
- Bone marrow involvement
- Disseminated intravascular coagulation (DIC)
- Fever
- Concomitant diseases
- Vitamin B12 or folate deficiencies

Platelet Growth Factors

- Thrombopoietin (TPO): Hormone thought to regulate platelet production
- Megakaryocytopoiesis
- Megakaryocyte growth and development
- Given to help increase platelet production to decrease effects of thrombocytopenia
- Interleukin-11: thrombopoietin growth factor
    - Stimulates bone marrow (BM) stem cells and megakaryocyte progenitor cells
- Nplate (romiplostim): Thrombopoietin receptor agonist used in treatment of idiopathic thrombocytopenia (ITP)
    - Contraindicated in Myelodysplastic syndrome (MDS)and hemolytic anemia pts
    - Use with caution in pts within chronic liver failure
- Platelet transfusions continue to be treatment of choice for therapy-related thrombocytopenia in oncology patients

Stem Cell Factors (SCF)

- Also known as mast cell factor, steel factor, or c-kit ligand
- Works on primitive progenitor cells
- Murine SCF: Enhance erythropoietin-dependent colony-forming unit
    - Can cause severe allergic reactions
        - Delay in product development!

Conclusion

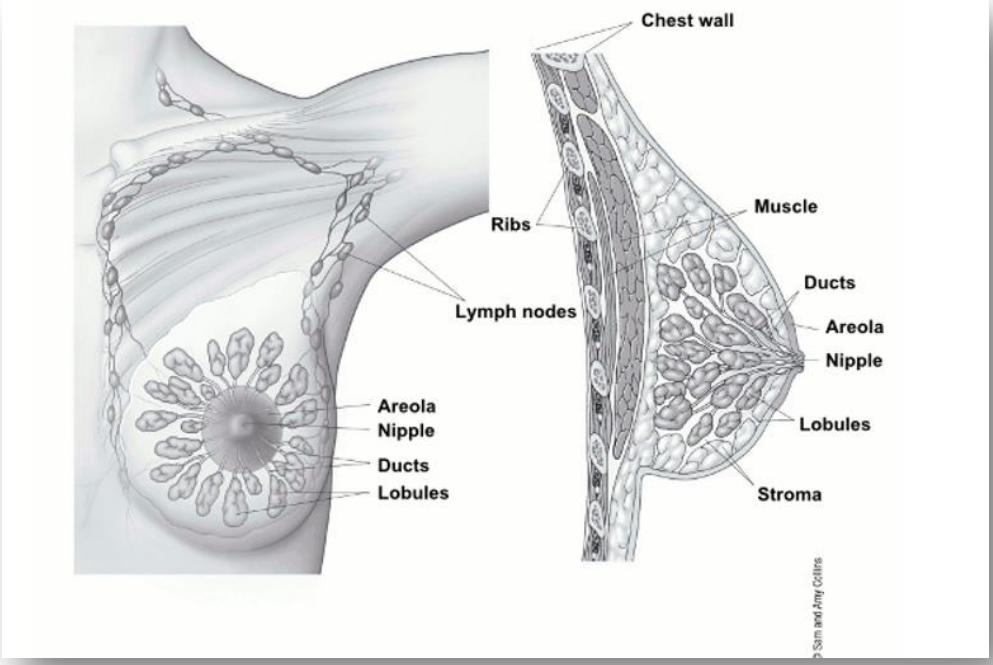
- Exercise caution when administering growth factors in oncology patients
  - Appropriate indications
  - Appropriate dosing
  - Document
- Educate patients
  - Teach them what to expect
  - Anticipate and manage side-effects
- Keep up to date on current practice recommendations

Hormonal Therapy: Breast Cancer

Breast Cancer

- Cells of the breast tissue start to grow out of control
- Once enough abnormal cells are present, these can be appreciated as a lump by the patient or seen on imaging such as mammogram
    - Can include malignant and non-cancerous tumors
- Ductal carcinomas: Cancers that begin in the ducts that bring milk to the nipple (most common)
- Lobular carcinomas: Cancers that begin in the glands that make milk
- Other cancers: Lymphomas, sarcomas
- DCIS/LCIS: Ductal and lobular carcinomas in situ that have not invaded the basement membrane

Normal Breast Tissue



Breast Cancer Burden

- Worldwide
  - Two million cases worldwide
  - Incidence greater in Western Europe vs Eastern Africa
  - Survival is greater than 80% in the US versus 40% in low income countries, mostly thought due to differences in screening and early detection
- United States
  - In 2020, an estimated 279,100 new cases of invasive breast cancer are expected to be diagnosed in women in the U.S., along with 62,930 new cases of non-invasive (in situ) breast cancer
  - About 2,670 new cases of invasive breast cancer are expected to be diagnosed in men in 2019
  - A man's lifetime risk of breast cancer is about 1 in 880.
  - About 41,760 women in the U.S. are expected to die in 2019 from breast cancer, though death rates have been decreasing since 1989

Risk Factors for Development of Breast Cancer

- Age: Over 55 has greater prevalence
- Sex: Females greater than males
- Genetics
  - BRCA1/BRCA2: Approximately 70% risk of breast cancer by age 80
  - Many others of variable/unknown risk: ATM, BARD1, CHEK2, PALB2
  - PTEN, and TP53
- Family history
- Race
  - White > African American > Asian American
- Breast tissue density
  - Exposure to estrogen
  - Alcohol consumption
  - Obesity
  - Physical activity
  - Decreased risk with increased physical activity

Detection of Breast Cancer

- History and physical exam
- Painless, hard lump or mass
- Swelling of the breast
- Nipple changes, retractions, or discharge
- Nodules, erythema, dippling on the skin

Imaging

- Mammogram: 3D with tomosynthesis
- Ultrasound
- MRI

_____
_____
_____
_____
_____

Biopsy

- Stereotactic
- Core vs fine needle

Pathological Examination

- Hormone receptors: Estrogen receptors (ER), progesterone receptor (PR)
- HER2 receptor testing
- Tumor size
- Ki67
- Nuclear grade and Nottigham score
- Lymph node sampling
- Final pathological staging

Treatment of Breast Cancer

- Chemotherapy: Is it needed
    - Oncotype, patient preference, comorbidities
    - Can be given in neoadjuvant, adjuvant, or metastatic setting
- Surgery
    - Lumpectomy
    - Mastectomy, bilateral mastectomies
    - Axillary lymph node dissection versus sentinel node evaluation
- Radiation
    - Mammosite
    - Hypofractionated
    - Whole breast
    - Boost to tumor bed/axillae
- Hormonal therapy
    - Selective estrogen receptor modulators (SERMs)
    - Selective Estrogen Receptor Downregulators (SERDs)
    - Aromatase Inhibitors (AIs)
- HER2 directed therapy
    - Trastuzumab, pertuzumab, neratinib, lapatinib, TDM-1

How Do We Suppress Estrogen?

- Naturally through aging: Menopause
- Medications
    - Luteinizing hormone releasing hormone (LHRH) analogues
    - SERMs
    - SERDs
    - AIs
- Surgery
    - Bilateral salpingoophorectomy
- Radiation
    - Ovarian irradiation

LHRH Antagonists

- Suppress ovarian function in pre- and peri-menopausal patients
- Initial increase in luteinizing hormone (LH) and follicle stimulating hormone (FSH), after continuous administration results in ovarian suppression and decreased estrogen
- Used to lower testosterone in prostate cancer
- Given as an IM injection every 1-3 months depending on drug, indication, and dose
- Side effects
    - Hot flashes, weight gain, edema, mood alterations, acne
- Three main drugs
    - Lupron (leuprolide)
    - Zoladex (goserelin)
    - Trelstar (triptorelin)

SERMs

- Mechanism of Action
    - Blocks the estrogen receptor in breast tissue
- Drugs in class
    - Nolvadex: Tamoxifen
    - Evista: Raloxifene
    - Fareston: Torimefene
- Indications
    - Cancer prevention in high-risk patients, pre-menopausal, post-menopausal, and men, only with ER positive disease
- Can be used in the neoadjuvant, adjuvant, locally recurrent, and metastatic setting
- Depending on the indication, may be taken for 1-2 years up to 10 years
- Side effects
    - Thrombolic events: Increased risk of DVT, PE, and stroke
    - Uterine malignancy: Adenocarcinomas and sarcomas
    - Menopausal symptoms: Hot flashes, night sweats, vasodilation, peripheral edema
    - Mood changes
    - Weight gain
    - Hyperlipidemia
    - Vaginal discharge

- Interactions with Selective serotonin reuptake inhibitor (SSRI)
    - Concomitant use with select SSRIs may result in decreased tamoxifen efficacy
    - Strong CYP2D6 inhibitors and moderate CYP2D6 inhibitors are reported to interfere with transformation to the active metabolite
    - Avoid grapefruit and grapefruit juice

Tamoxifen

- Pre- and Post-menopausal women for adjuvant therapy
  - 20mg daily for 5-10 years
- Treatment of DCIS and prevention of invasive malignancy
  - 20mg daily for 5 years
- Breast cancer risk reduction in high-risk lesions or family history
  - 20mg daily for 5 years
- Treatment of metastatic disease
  - 20-40mg daily until toxicity or progressive disease

SERDs

- Mechanism of Action
  - Block the effects of estrogen in the breast tissue
  - May also reduce the number of estrogen receptors and change the shape of the receptor so that estrogen cannot bind
- Drugs in class
  - Faslodex (fulvestrant)
    - Indications: ER positive advanced or metastatic breast cancer in post-menopausal women
    - Dosing is the same for all
      - 500mg IM gluteal injection days 1, 15, 29, and then every 28 days until disease progression or toxicity
    - Side effects
      - Fairly well tolerated overall
      - Fatigue, hot flashes, GI symptoms, increased AST/ALT
      - Injection site reaction/discomfort/medication leakage
    - Interactions
      - No significant interactions

AIs

- Mechanism of Action
  - Inhibits aromatase
- Drugs in Class
  - Arimidex (anastrozole)
  - Femara (letrozole)
  - Aromasin (exemestane)
- Indications: Neoadjuvant, adjuvant, or metastatic breast cancer treatment in post-menopausal women in ER positive breast cancer
- Side effects
  - Hot flashes, night sweats, fatigue
  - Arthralgias, myalgias
  - Decreased bone density
  - Mood alterations
  - Vaginal dryness, decreased libido
  - Weight gain
  - Increased AST/ALT
- Drug interactions
  - May increase serum concentration of methadone
  - Exemestane has more interactions, especially strong CYP 3a4 inducers: Anti-seizure medication
- Many schemata of administration depending on indication/use
  - ONLY for post-menopausal women
  - 5-10 years after surgery/chemo in adjuvant setting
  - Neoadjuvant to downsize tumor for optimal surgical results
  - After 1-2 years of Tamoxifen
  - Continuously in the metastatic setting until unacceptable toxicity or progressive disease
  - In conjunction with ovarian suppression in pre-menopausal women
- Arimidex
  - Nonsteroidal
  - 1mg daily
- Femara
  - Nonsteroidal
  - 2.5mg daily
- Aromasin
  - Steroidal and irreversibly binds to enzymes
  - 25mg daily

Aromatase Inhibitors with CDK 4/6 inhibitors

- CDK 4/6 inhibitors: Reduce proliferation of breast cancer cell lines by preventing progression from G1 to S cell cycle phase
- CDK 4/6 inhibitors used in conjunction with AIs to inhibit tumor growth
- Very effective combination for recurrent/metastatic ER positive breast cancer with efficacy rates similar to chemotherapy
- Three drugs now available: Palbociclib, ribociclib, and abemaciclib

Management of Anti-Estrogen Side Effects

- Decreased bone density
    - Encourage weight bearing exercise
    - Calcium, vitamin D supplements
    - DEXA scans every 2 years
    - Medications like Fosamax, Boniva, Reclast, Prolia
- Arthralgias/myalgias
    - Encourage exercise and regular activity
    - Ibuprofen, acetaminophen, COX 2 inhibitors
- Weight gain
- Mood alterations
- Hot flashes
    - Effexor, gabapentin
    - Yoga, layering clothing, avoiding alcohol
- Cardiac events
    - Monitor in conjunction with PCP

AIs vs. SERMs

- Effectiveness
    - Decreased risk of breast cancer recurrence and mortality with AIs
- Side effects
    - Bone density: Worse with AI
    - Musculoskeletal: Worse with AI
    - Thromboembolic disease: Worse with Tamoxifen
    - Uterine effects: Worse with Tamoxifen

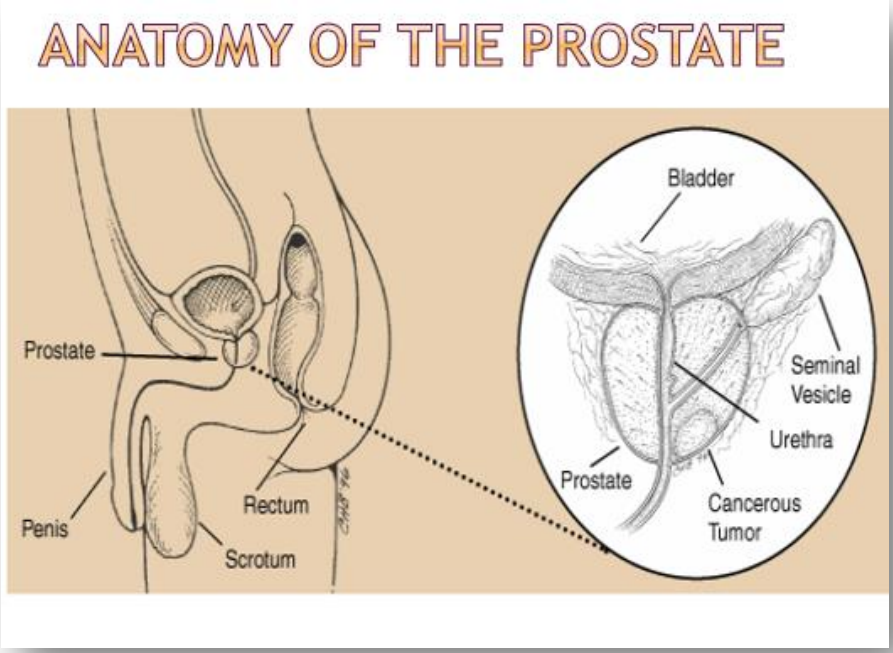
Overview of Treatment

- Premenopausal
  - Tamoxifen alone
  - LHRH agonist/ovarian suppression with AI
- Postmenopausal
  - SERMs, SERDs, AIs
- Adjuvant
  - SERMs, AIs, LHRH agonists or ovarian suppression
- Metastatic/Recurrent disease
  - SERMS, SERDS, AIs, LHRH agonists
- Men
  - Tamoxifen

Hormonal Therapy: Prostate Cancer

Treatment Options for Prostate Cancer

- Hormonal therapy options
  - Mechanism of action
  - Indications
  - Side effects
  - Dose and Administration
  - Drug interactions



Epidemiology

- Estimates in 2020: 191,930 new cases, 33,330 deaths from prostate cancer
- Most commonly diagnosed cancer in men, (1 out of 7 men)
- Second leading cause of death from cancer in men (1 out of 38 men)

Age

- More common after age 65
  - Mean age = 66

The risk factors of prostate cancer include

A. Being of African descent
B. Being under 50 years of age
C. Having a first-degree relative who has been diagnosed with prostate cancer
D. A and C

Risk Factors

- Age: Six out of ten > 65 years old
- Race/Ethnicity: African American > Whites > Asians > Hispanics
- Geography: North America, Northwest Europe, Caribbean
- Family History: Risk multiplies with family history
- Gene Changes: BRAC1, BRAC2, Lynch syndrome
- Diet: Red meat, high-fat diary, calcium, vitamin E
- Obesity: Higher risk, more aggressive form
- Smoking: Not enough data
- Workplace exposures: Toxic combustion products
- Inflammation: Prostatitis
- Sexually transmitted disease (STD)/Vasectomy: Not enough data

Screening recommendation

- Average Risk
  - Age 50
  - Digital rectal exam (DRE)
  - Prostate Specific Antigen (PSA)
- High
  - Age 40-45
  - DRE
  - PSA
- Frequency
  - PSA < 2.5 – Every two years
  - PSA > 2.5 – Every year

Signs and Symptoms

- Early stage
  - asymptomatic
- Advanced stage
  - Problem urinating
  - Hematuria
  - Erectile dysfunction
  - Bone pain
  - Weakness, numbness, edema
  - Weight loss

Treatment Options

- Observation
- Surgery
- Radiation
- Hormone therapy
- Chemotherapy

Reasons for Hormone Therapy

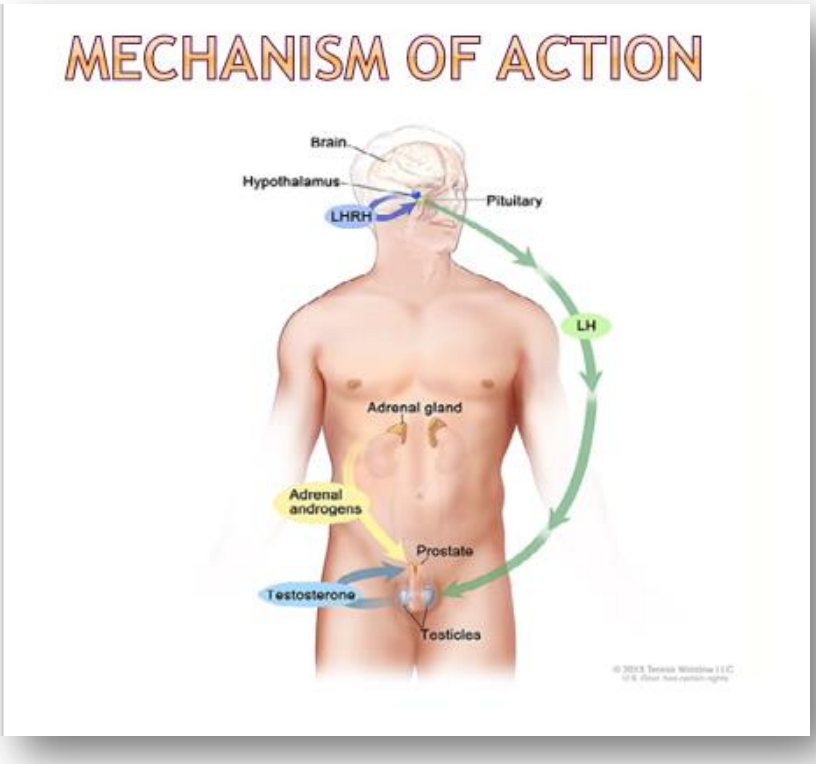
- Localized disease
- Metastatic disease
- Recurrent disease
- Adjuvant therapy

Hormonal Therapy

- Traditional hormone therapy
    - Orchiectomy
    - Luteinizing hormone-releasing hormone (LHRH) analogs
- New hormone therapy
    - CYP17 blocker
    - Androgen receptor inhibitor
- Other treatments
    - Estrogens
    - Ketoconazole

Traditional Hormone Therapy

- Luteinizing hormone releasing hormone (LHRH) agonists
    - Lupron (Leuprolide)
    - Zoladex (Goserelin)
    - Trelstar (Triptorelin
- LHRH antagonists
    - Firmagon (Degarelix)
- Anti-androgens
    - Eulexin (Flutamide)
    - Casodex (Bicalutamide)
    - Nilandron (Nilutamide)



LHRH Agonists

- First line therapy
- Eliminates 90-95% of androgen production
- Initial 80-90% response rate
- Can cause “flare reaction”
- Take anti-androgen agent to prevent flare reaction

Dose

- Lupron: Eligard
    - 7.5 mg IM/SQ every month
    - 22.5 mg IM/SQ every three months
    - 30 mg IM/SQ every four months
    - 45 mg IM/SQ every 6 months

LHRH Antagonist

- Firmagon (degarelix)
    - Dose: Loading dose 240 mg SC followed by 80 mg SC monthly
    - Reduce testosterone level quickly
    - Do not cause tumor flare

Side Effects: LHRH Analogs

- Acute
  - Gynecomastia
  - Hot flashes
  - Fatigue
  - Depression
  - Erectile dysfunction
  - Edema
  - Injection site reaction
- Long-term
  - Osteoporosis
  - Obesity
  - Cardiovascular events
  - Insulin resistance
  - Alterations in lipids
  - Increased risk of diabetes

Anti-Androgens

- Oral medications
- Often used with other agents
  - To boost first line therapy
  - To achieve combined androgen blockade (CAB)
- Given for few weeks to prevent flare reaction with LHRH agonists

Dose

- Eulexin: 250 mg PO every 8 hours
- Casodex: 50 mg PO daily
- Nilandron: 300 mg PO daily for thirty days then 150 mg PO daily

Side Effects: Antiandrogens

- Common
  - Hot Flashes
  - Gynecomastia
  - Nausea /vomiting /diarrhea
  - Impotence
  - LFT abnormalities
  - Individual drugs
- Fluamide/Bicalutamide
  - Can increase a risk of bleeding/warfarin
- Nilutamide
  - Vision problems, scarring and inflammation of the lung

New Hormonal Therapy

- CYP 17 inhibitor
- Androgen receptor inhibitor

DZ is a 64-year-old male with Stage IV prostate cancer. He is about to start therapy with the LHRH agonist leuprolide. He has metastatic bony disease. To prevent tumor flare in this patient what do you recommend?

A. Leuprolide alone
B. Leuprolide + flutamide
C. Leuprolide + finasteride
D. Leuprolide + ketoconazole

Zytiga (abiraterone)

Indication

- Castrate resistant metastatic prostate cancer
- Usually used with LHRH agonist/antagonist

Warnings/Precautions

- Cardiovascular disease
- Hepatic impairment

Dose and Administration

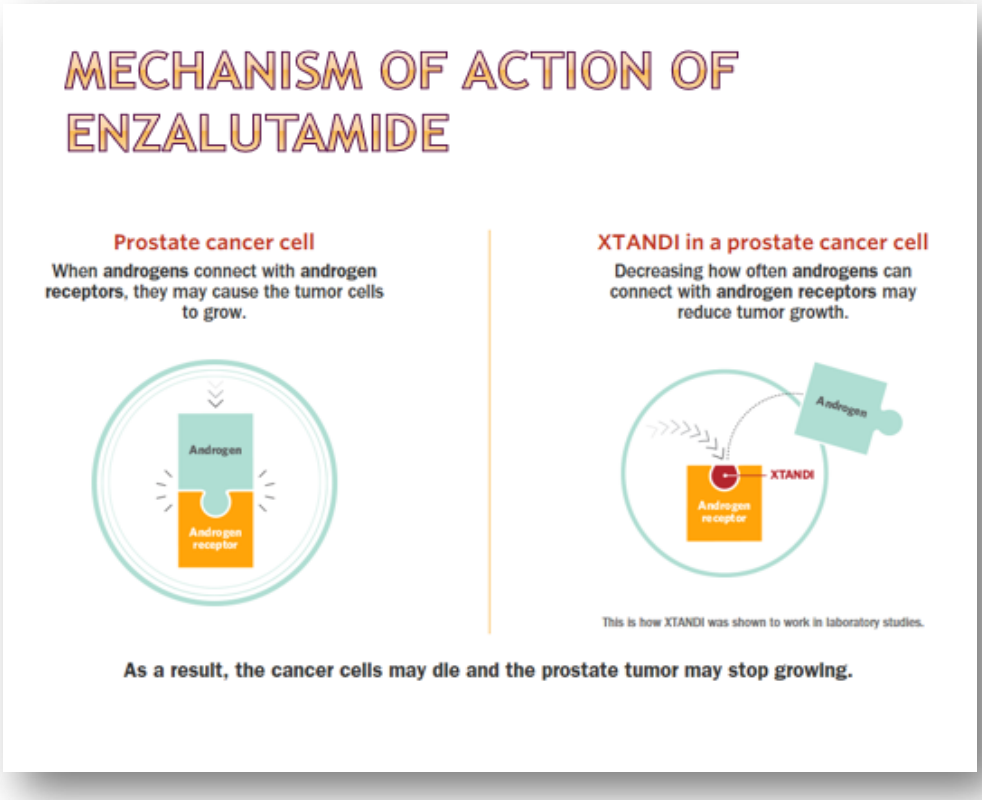
- 1000 mg PO every day with 5 mg predinsone PO twice a day
- At least one hour before meals or two hours after meals

Drug Interactions

- Strong CYP3A4 Inducers: Increase dosing frequency of abiraterone once a day to twice a day
    - Carbamazepine
    - Dexamethasone
    - Fosphenytoin
    - Nafcillin
    - Oxcarbazepine
    - Phenytoin
    - Rifampin

Side Effects of Abiraterone

- Hypokalemia
- Hypertension
- Fluid retention
- Hepatotoxicity
- Fatigue
- Joint swelling/discomfort
- Hot Flashes
- Hypercholesterolemia
- N/V, Diarrhea



Xtandi (enzalutamide)

Indications
- For castrate resistant metastatic prostate Cancer
- Usually used with LHRH agonist

Warning and Precautions
- Seizures

Dose and Administration
- 160 mg PO daily
- Take with food

Drug Interactions

- Strong CYP 3A4 Inducers: Increase the dose of enzalutamide to 240 mg
  - Carbamazepine
  - Dexamethasone
  - Fosphenytoin
  - Nafcillin
  - Oxcarbazepine
  - Phenobarbital
  - Phenytoin
  - Rifampin
  - St John's wort
- Strong CYP 2C8 Inhibitors: Reduce dose to 80 mg
  - Gemfibrozil
- Strong CYP 2C8 Inducers
  - Rifampin

Side Effects of Enzalutamide

- Common
  - Back/joint/muscle pain
  - Hypertension
  - Fatigue/joint swelling/discomfort
  - Headache, dizziness
  - Hot flashes
  - Constipation, diarrhea
  - Upper respiratory tract infection
  - Neutropenia

Other Agents

Estrogens: Female Hormones

- Used when first line therapy not working or tolerated
- Diethylstilbestrol (DES)
- Risk of blood clots and breast enlargement

Ketoconazole

- Blocks androgens and cortisol
- 400 mg three times a day
- Use with corticosteroid
- Side effects: Nausea/vomiting, impotence, gynecomastia, dry skin, increased LFTs
- Multiple interactions

Current Issues

- Treating early stage cancer
- Early vs. delayed treatment
- Intermittent vs. continuous hormone therapy
- CAB
- Triple androgen blockade (TAB)
- Castrate resistance and hormone refractory prostate cancer

Hypersensitivity Reactions and Chemotherapy

Hypersensitivity

- Excessive, undesirable, damaging, discomfort producing, and sometimes _____ reactions produced by the normal _____ system in response to an antigen or allergen
- The types of reaction are divided into four categories based on the mechanisms involved and the time taken for the reaction

Signs and symptoms of anaphylaxis include: Select all that apply

1. Diaphoresis
2. Fatigue
3. Itching around an intravenous insertion site
4. Pain around the IV insertion site
5. Urticaria

Types of Hypersensitivity Reactions

- Type I
    - Most common type associated with _____ agents
    - Potential for anaphylaxis
    - Occur after _____ exposure
        - Antibody formation and release of chemical mediators
- Mechanism of action
    - Immediate _____ mediated reaction
    - Mediator release from basophils and mast cells

Signs and Symptoms

- _____
- Rash
- N/V
- Flushing
- Urticaria
- Bronchospasm
- _____
- Angioedema
- Anxiety/impending doom

Anaphylaxis

- Any reaction that leads to widespread activation of _____ _____ and basophils
    - Activated mast cells or basophils subsequently release pro-inflammatory mediators or cytokines, thereby causing the clinical manifestations of allergy
- The goal should be early recognition and appropriate management of anaphylaxis in its milder form, before anaphylactic shock is reached
- Different from other reactions because anaphylaxis is likely to recur despite pre-medications and typically becomes more severe upon re-exposure

_____
_____
_____
_____
_____

Types of Hypersensitivity Reactions

Type	Mechanism of Action	Signs and Symptoms	Examples
I	IgG or IgM antibody-mediated reaction results in antibody-antigen complexes that cause inflammation	Hemolysis	Hemolytic anemia, hemolysis from transfusion
II	Immune complex-mediated reaction cause by antigen-antibody interactions. Complexes form in circulation and deposit in various tissues	Tissue injury; vasculitis, nephritis, arthritis	Systemic lupus, rheumatoid arthritis
IV	Cell-mediated or delayed-type reaction due to sensitized T lymphocytes that interact with antigen	Contact dermatitis, homograft rejection, granuloma formation	Tuberculosis, granulomas, poison ivy

Cytokine Release Syndrome (CRS)

- A _____ inflammatory response due to high circulating levels of inflammatory cytokines released from the immune cells affected by the treatment
- A condition that may occur after treatment with some types of _____, such as monoclonal antibodies and CAR T-cells

Reactions

- Infusion/Anaphylactic
    - Immune-mediated response in a sensitized patient
        - IgE
    - Changes in response to an antigen or foreign substance
    - Allergic
    - Often reacting to vehicle, not drug
- CRS
    - More often occurs with use of biological agents
    - Release of cytokines: From T-cells
    - Non-allergic
- Cytotoxic agents most commonly associated with infusion reactions
    - Taxanes: Paclitaxel, docetaxel
    - Platinum drugs: Carboplatin, oxaliplatin
    - L-asparaginase
    - Etoposide
        - Reaction in the first few minutes to hours after dose
    - Procarbazine
        - Corticosteroid recommended before infusion
    - Monoclonal antibodies
        - Most of these reactions are related to cytokine release rather than murine exposure
        - Reaction is greater during first treatment

_____
_____
_____
_____
_____

- Timing
  - Infusion reactions usually occur during or within a _____ hours of drug infusion
  - A reaction may occur _____ to _____ days after administration, and patients must be adequately informed of symptoms to watch for
- Incidence
  - Overall Incidence rate of severe reactions: _____ - with proper pre-medications and monitoring
  - Overall incidence rate of mild to moderate: _____
  - Varies by drug _____ and diagnosis

Incidence

High Potential	Occasional Potential	Rare Potential
• L-Asparaginase • Cytarabine • Taxanes • Platinum compounds • Procarbazine • Etoposide • Bleomycin • Liposomal	• Anthracyclines	• Cyclophosphamide and ifosfamide • Dacarbazine • 5-FU • Hydroxyurea • Methotrexate • Vincristine and vinblastine

Biotherapy Drugs Associated with Hypersensity Reactions and Cytokine Release Syndrome: Monoclonal Antibodies

Chimeric	Humanized	Fully Human
• Cetuximab • Rituximab	• Alemtuzumab • Bevacizumab • Trastuzumab	• Panitumumab • Nivolumab • Olaratumab

Incidence Rates	
Rituxan	77% reaction rate 50% of reactions within initial infusion
Trastuzumab	Up to 40% reaction rate
Cetuximab	16%-19% reaction rate Increased rate in southwest region of U. S.
Platinums (carboplatin and oxaliplatin)	12%-19% reaction rate
Paclitaxel	8%-45% reaction rate
Docetaxel	• 5%-20% reaction rate
Etoposide	• 1%-3% reaction rate • As high as 51% in study of Hodgkin's Lymphoma

True or False?
50% of Rituxan (rituximab) reactions occur during the initial treatment?

_____
_____
_____
_____
_____

Risk Factors

- Drug Risk Factors
  - Class of _____
  - _____ of drug
  - Route of drug
  - _____ at which drug is given
- Cycle number
- Patient Risk Factors
  - Pre-existing allergies/asthma/autoimmune disease
  - High circulating lymphocyte counts (>25,000/mm^3)
  - Gender
  - Age
  - New patient/diagnosis
  - Type of cancer diagnosed
  - Platins
    - _____ number of cycles
    - Extended period of time between cycles
  - Taxanes
    - Early cycles
    - Respiratory dysfunction
    - Obesity

Signs and Symptoms of Infusion Reaction

- _____
- Itching
- Alterations in heart rate and _____
- Dyspnea or chest discomfort
- Back or abdominal pain
- _____ and/or chills and shaking
- Nausea, vomiting, and/or diarrhea
- Skin rash
- Throat _____
- Hypoxia
- Seizures
- Dizziness and/or syncope

A patient's risk for anaphylaxis increased when medications are:

A. Given as a single dose
B. Given at a low dose
C. Given intravenously
D. Synthetically prepared

_____
_____
_____
_____
_____

Signs and Symptoms of Anaphylaxis

- Cutaneous symptoms
  - _____
  - Urticaria
  - Angioedema: Usually of face, eyelids, or lips
- Respiratory symptoms
  - Repetitive cough
  - Sudden nasal _____
  - Shortness of breath (SOB)
  - Chest tightness
  - Wheeze
  - Sensation of throat closure or choking
  - Change in voice quality: Due to laryngeal edema
  - Hypoxia
- Cardiovascular symptoms
  - Faintness
  - _____ or less often-bradycardia
  - Hypotension or hypertension
  - Loss of conscience
- GI symptoms
  - _____
  - Vomiting
  - Abdominal cramping
  - Diarrhea

- Neuromuscular symptoms
  - Sense of impending _____
  - Tunnel vison
  - Dizziness, and/or seizure
  - Severe back, chest, or pelvic pain

Timing of Symptoms

- Platinums
  - Period of sensitization
  - _____ treatments
- Taxanes
  - _____ dose
  - Within 5-10 minutes
- Monoclonal antibodies
  - _____ doses
  - Rituximab

_____
_____
_____
_____
_____

Management and Prevention of Reactions

- Management: _____ the infusion _____
- Stay _____
- Maintain the IV line
    - Begin flushing with compatible IV fluid
- Call for help and obtain a set of vital signs
- Oxygen if necessary
- Call the advanced professional practitioner or physician
- Do not _____ the patient _____
- Evaluate symptoms
- Administer _____ histamine antagonists/corticosteroids/bronchodilators
- Monitor vital signs Q15 minutes for one hour
- Continue or discontinue chemotherapy as ordered
- If the patient becomes unstable
    - Maintain patent airway
    - Place patient in supine position unless contraindicated by respiratory distress
    - Call a condition if symptoms do not resolve or patient is in distress

Management

- Mild to moderate _____ are considered grades 1 or 2 and do not involve symptoms of anaphylaxis
- These are the most common
- Management involves temporary interruption of the infusion and symptom management
- Treatment of severe infusion reaction (grade 3 or 4) and anaphylaxis requires discontinuation of the drug infusion and immediate treatment with epinephrine and antihistamines
- Rechallenging
    - Physician driven
        - Within 30-60 minutes of acute reaction
        - Next treatment and extra premeds on board
        - Not usually attempted if true anaphylactic event
- Desensitizing
    - _____ dose → _____/goal dose within hours
    - Temporary
    - Allergist supervision and 1:1 nursing care
    - Often in ICU
    - Multiple protocols
        - 12 step, 16 step, etc.
    - Safe and effective way of getting first line treatment

_____
_____
_____
_____
_____

Medications for Infusion Reaction/Anaphylaxis

- Albuterol inhaler for severe _____
- Benadryl 50 mg IVP to relieve _____ and urticaria
- Epinephrine auto-injector 0.3mg/0.3ml IM every 5-15 minute as needed into, mid-outer thigh
- Hydrocortisone 100 mg-250 mg IVP to suppress rebound reaction
- Lorazepam 0.5 mg-4 mg IVP for anxiety
- Methylprednisolone 50-100 mg IVP to suppress rebound reaction
- Pepcid 20 mg IVP Relieve itching and urticaria

Prevention

- Identify risk factors
- Pre-medications
    - Antihistamines
    - Corticosteroids
    - Antiemetics
    - Pepcid
- Atypical premeds if history of reaction
- Extra steroid doses

When your patient begins to have a reaction, you are to stay calm and do what first?

A. Explain to the patient what is occurring to alleviate anxiety
B. Leave the room to call a physician
C. Remove the IV
D. Stop the infusion

A patient with ovarian carcinoma agrees to participate in a clinical trial involving a new agent with anaphylactic potential. What precautions should the nurse take the first time the drug is given?

A. Administer the agent only in an environment where emergency medication and equipment are available
B. Pre-medicate the patient with diazepam
C. Reject the patient as a candidate for the study
D. Take the vital signs before the agent is administered and every four hours thereafter

_____
_____
_____
_____
_____

Documenting the Incident

- Patient's _____ prior to reaction
- Patient's signs/symptoms during reaction
- All vital signs taken _____ to infusion and ongoing assessment of the patient
- All interventions _____ reaction
- RiskMaster
- Allergy/side effect(s) to the medication
- Patient education
    - Potential for reactions post treatment
    - Seek emergency care at first signs
    - Alert other health care providers and known necessary premeds

Blood Products

Packed Red Blood Cells	Platelets
• Any time during transfusion • Most commonly see rigors/hives/pruritis/fever • Treat appropriately • Do not flush line during subsequent treatments • Larger Benadryl dose and/or addition of steroid	• Usually toward end of transfusion • Most commonly see hives/pruritus • Treat appropriately • Do not flush line during subsequent transfusions • Add steroid as premedication

Emend

- Irritating to vein
- Patients commonly have hypersensitivity
- Give slower through peripheral IV's and first-time doses

Have you ever been involved in a situation in which a patient reacted while receiving cancer treatment?

A. Yes
B. No

_____
_____
_____
_____
_____

Cytokines, L-asparaginase, and Vaccine

Interferons (IFNs)

- Earliest biotherapy agents: Discovered 1957
- Family of glycoproteins
- Production stimulated by various infections
- Immunoregulatory functions
- Designated α, β, γ, and ω on the basis of association with certain producer cells and functions
- All animal cells can produce interferons
- Used as antineoplastics and biological response modifiers

Biological Activity

- Inhibition of oncogenes
- Inhibition of viral replication
- Promotion of dendritic-cell development
- Increase function of immune effector cells
- Antiangiogenic effects
- Direct antiproliferative effects

Types and indications

- IFN – β (beta): 1a and 1b
  - 1a: Avonex®, Rebif®, CinnoVex®
  - 1b: Betaferon®, Betaseron ® Extavia®, Ziferon®
- IFN- γ(gamma)/(Actimmune®)
  - Chronic granulomatous disease
- IFN- α (alpha): 2a and 2b
  - *2a* (Roferon®): Hairy cell leukemia, AIDS related Kaposi's sarcoma, CML, chronic hepatitis C, adjuvant in malignant melanoma
  - *2b* (Intron® A): Condyloma acuminatum (epidermal manifestation related to HPV cause increased cancer risk in men and women), hepatitis B and C, hairy cell leukemia, high risk malignant melanoma, AIDS related Kaposi's sarcoma
  - *2b* (Sylatron®): Melanoma

Pharmacokinetics

- Metabolized and excreted primarily by the kidneys
- Well-absorbed following SC/IM injection
- Peaks at 6-8 hours

Adverse Effects

- Flu-like symptoms
  - Fever, chills
  - Malaise
  - Arthralgias
  - Fatigue
- Hypotension
- Nausea
- Anorexia/weight loss
- Taste changes
- Xerostomia
- Myelosuppression
- Hypothyroidism
- CNS Effects
  - Impaired memory
  - Poor concentration
  - Seizures
  - Paranoia
  - Hallucinations
  - Psychoses
  - Somnolence
  - Irritability
  - Headache

Management of Adverse Events (AEs)

- Fatigue
  - Intermittent schedule better tolerated
  - Taking drug at bedtime may help
- Flu-like syndrome
  - Symptoms diminish with repeated injections
  - Best managed with acetaminophen

Dosing

- Single doses can range from 2 million international units (MIU) to at least 35 MIU/m^2
- Check specific protocol/regimen
  - Melanoma: 3 MIU once a day for 48 weeks
  - CML: 9 MIU QD x 18 months
  - Kaposi's sarcoma = 3 million IU's once a day for 12 weeks
- Verify brand of IFN ordered
- Dosing is not interchangeable
- Drug is given SC, IM, IV

Dose Modifications

Symptom	Evaluation	Hold dose/resume	Dose modifications
Anorexia	Calorie counts	Missing three meals for seven days in one week	33-50% with nutrition consult
Weight loss	> 10% weight loss	> 10% weight loss in one week	33-50% with nutrition consult
Fatigue	Thyroid function	≥ 2 level decline in ECOG PS in 1-2 weeks	33-50% after dose delay of 1-2 weeks
Depression	Beck's evaluation	Moderate depression for 1-2 weeks	33-50% with psychiatric eval
AST	Liver function tests (LFTs)	> 10 times normal limit: Return to 3 times normal limit	33-50% when LFTs are < 3 times normal limit
WBC	Absolute neutrophil count (ANC)	< 250/mm^2 for one week	33-50% when ANC > 250/mm^2

Nursing Care Issues

- Chemotherapy safety: Low risk
- Patient education
  - Self-injection
  - Signs/symptoms of infection, bleeding, nutrition
  - Symptom management
  - Skin care
  - Contraception
- Assess for depression on each contact
- Manufacturer tools for patient education and support

Which of the following toxicities associated with use of IFN improves with continued use?

A. Fatigue
B. Neutropenia
C. Flu-like symptoms
D. Depression
E. Anemia

Interleukin 2 (IL2)

- Biological response modifier
- Modifies the relationship between the immune system and the tumor

Biological Activity

- Promotes proliferation, differentiation, and recruitment of T and B cells, natural killer (NK) cells and thymocytes
- Causes cytolytic activity in lymphocytes that leads to interaction between immune system and malignant cells
- Can stimulate lymphokine-activated killer (LAK) cells and tumor-infiltrating lymphocyte (TIL) cells

Indications

- Labeled Indications
  - Metastatic renal cell carcinoma
  - Metastatic melanoma
- Additional use
  - Tumor infiltrating lymphocyte protocols

Pharmacokinetics

- Metabolized and excreted by the kidneys
- Half-life distribution: 13 minutes
- Elimination half-life: 85 minutes

Adverse Effects

- Cytokine-induced capillary leak syndrome (CLS)
  - Hypotension
  - Visceral edema
  - Dyspnea
  - Tachycardia
  - Arrhythmia
  - Atrial fibrillation
- Increased liver function tests
- Pruritis
- Flu-like symptoms
  - Fever, chills, rigors
  - Malaise
  - Arthralgias/myalgias
- Neurotoxicity
- Infection
- Oliguria, increase creatinine
- Myelosuppression
- Nausea/vomiting/diarrhea (N/V/D)
- Earliest manifestations of CLS: Hypotension, tachycardia, fever, chills
  - Approximately 2 hours after first dose

_____
_____
_____
_____
_____

- Oliguria frequently manifests in first 24 hours
- Nausea/vomiting/diarrhea become more prominent toward end of therapy
- Edema, weight gain, and pulmonary congestion are progressive with treatment
- Majority of side effects reverse with termination of IL-2, most patients ready for discharge 1-3 days after last dose

Dosing

- Metastatic renal cell carcinoma and metastatic melanoma
    - 600,000 IU/kg every 8 hours for a maximum of 14 doses
    - Repeat after 9 days for a total of 28 doses/course
    - Decision to continue treatment usually made after 2 courses (4 cycles)
    - Continue if response observed

Monitoring

- Daily
    - CBC with diff
    - CMP
    - Weight
    - Strict I/Os
- Routinely
    - Vitals
    - I/Os

Dosing Issues

- No dose reductions: Only omissions
- Doses are held according to symptomatic recovery from the previous dose
- A delay longer than 3 doses (24 hours) should result in discontinuation of cycle
- Guidelines for delay or discontinuation of IL-2 therapy are based on relative and absolute criteria
- Action taken based on various criteria
    - With appropriate corrective therapy and time delay to allow for recovery, patients with relative criteria may receive another IL2 dose
    - Presence of any absolute criteria that is not easily reversible is generally an indication to stop therapy

Monitoring and Interventions

- Fever/chills/myalgias
    - Prophylactic APAP and indomethacin
    - Breakthrough
        - Increase frequency of indomethacin
        - Consider infectious disease workup if fever within first 24 hours

- Blood pressure
  - Goal SBP 80-90
  - Aggressive fluid resuscitation: Crystalloid > colloid
  - Vasopressor support PRN: Phenylephrine 40mg/100mL
    - 0.1 to 2mcg/kg/min
      - Titrate to response
- Renal function/urine output
  - Oliguria
    - IVF
    - Low-dose dopamine at 2 mcg/kg/min
  - Goal: Urine output 10 to 20 mL/hour
- Arrhythmias
  - Stop IL2 therapy
  - Correct electrolytes, anemia, hypoxia
  - Administer supportive care medications PRN
- Pulmonary
  - Goal: O_2 saturation ≥ 95%
  - If not maintained with supplemental O_2, discontinue
  - Do not use inhaled corticosteroids
- Edema/weight gain
  - Result of IVF for BP and oliguria
  - Do NOT use diuretics during therapy
    - Ineffective and dangerous
  - Patients will likely auto-diurese after completion of therapy
- Gastritis, nausea, vomiting, diarrhea
  - Prophylactic prochlorperazine 10 mg every 6 hours
  - PRN N/V
    - Haloperidol 0.5 mg every 6 hours IV
    - Prochlorperazine 10 mg every 6 hours IV
    - Ondansetron 4 mg every 6 hours IV
    - Lorazepam 0.5-1 mg every 6 hours PO/IV
- PRN diarrhea
  - Loperamide 2 mg every 3 hours PO
  - Diphenoxylate: 2.5 mg/atropine 25 mcg every 3 hours PO
- Electrolyte disturbances
  - Hypocalcemia
    - Goal: Maintain above lowest normal value
    - Calcium gluconate, 10% 1 gram over 1 hour IV
  - Hypokalemia
    - Goal: Maintain above 3.6 mmol/L
    - Potassium chloride 10 mEq over 1 hour IV
  - Hypomagnesemia
    - Goal: Maintain above lowest normal value
    - Magnesium sulfate 1 gram over 1 hour IV

    - Hypophosphatemia
        - Goal: Maintain above lowest normal value
        - Potassium phosphate 10-15 mmol over 6 hours IV
    - Hypoalbuminemia
        - Observe
- Hematologic
    - Anemia: Transfuse packed red blood cells (PRBCs) PRN
    - Thrombocytopenia: Transfuse PRN
- Acidosis
    - Infuse sodium bicarbonate IV PRN
- Dermatologic
    - Oatmeal baths and non-steroidal lotions
    - Hydroxyzine 10-20 mg PO every 6 hours
    - Diphenhydramine 25–50 mg IV/PO every 6 hours
- Neurologic
    - Agitation and/or combativeness
        - Haloperidol 1- 5 mg IV/IM PRN
    - Anxiety
        - Lorazepam 0.5 -1 mg PO/IV every 6 hours PRN
    - Insomnia
        - Temazepam 15 -30 mg qhs PO
        - Zolpidem 5 -10 mg qhs PO
- Infections
    - Prevention of line sepsis
        - Cephalexin 250 mg PO BID
        - Ciprofloxacin 500 mg PO BID
    - If infection is suspected, discontinue IL2 and treat

Nursing Care Issues

- Consider stopping antihypertensives before admission (24 hours)
- No steroids
- Chemotherapy safety: Low risk
- Drug incompatible with NSS: Only D5W
- Do not filter
- Incompatible with other drugs
- Use plastic IV bags
- Administer IV over 15 minutes

Which of the following symptoms is NOT related to capillary leak syndrome?

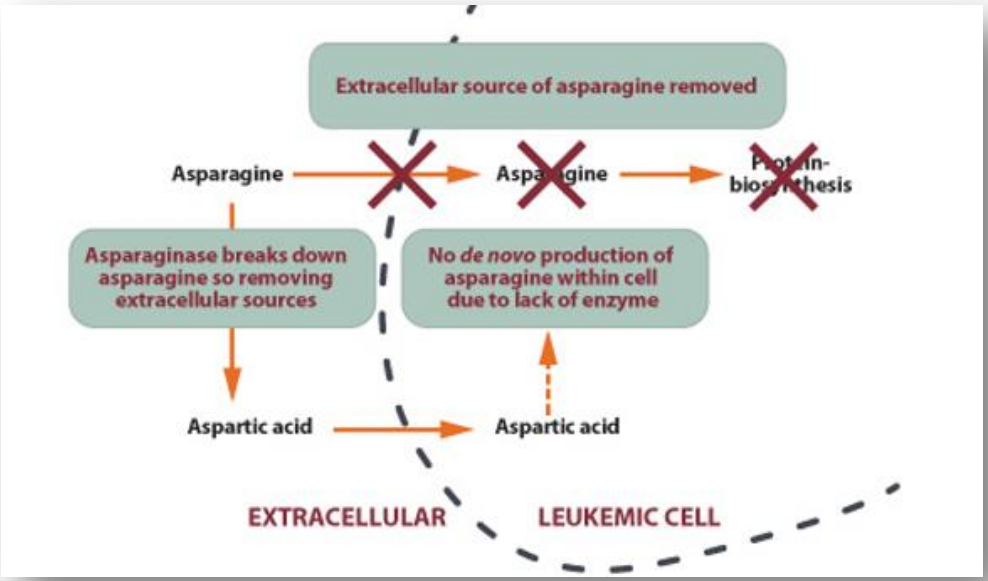
A. Hypotension
B. Fever
C. Tachycardia
D. Oliguria
E. Edema

_____
_____
_____
_____
_____

L-asparaginase

- Enzyme that capitalizes on the inability of lymphoid cancer cells to synthesize L-asparagine: Amino acid
- Lymphoid cells need L-asparagine but can't make it
- Lymphoid cells depend on a circulating supply to proliferate
- L-asparaginase breaks down L-asparagine in the circulating supply (to NH3 and aspartic acid)
- Leukemia cells die due to the inability to acquire the amino acid: L-asparagine
- FDA-approved use: ALL

L-asparaginase Mechanism of Action



Two Types

- Erwinaze: Erwinia asparaginase
  - Derived from Erwinia chrysanthemi: A gram negative bacillus
- Oncaspar: Pegylated asparaginase
  - Pegylated: Attachment of a polyethylene glycol (PEG) polymer chain to another molecule
  - For patients with hypersensitivity to other formulations
  - Extended duration of action and possibly less immunogenicity
  - Most commonly used in pediatrics

Dosing and Administration

- Protocol/regimen/product specific dosing
- IM route
    - Not more than 2 ml in one site
    - Check site for erythema after dose
- IV route
    - Can cause phlebitis: Y-site through running IV
    - PEG formulation: Give in 100ml NSS/D5W over 1-2 hours

Pharmacokinetics

- Drug remains primarily in plasma and lymphatic fluid
- Cleared by phagocytes
- No renal or hepatic involvement
- Does not effectively cross the blood/brain barrier

Adverse Effects

- Pancreatitis
- Hepatitis
- Anaphylaxis
- DIC
- Fever

Hypersensitivity

- Occurred in $\geq$ 30% of patients receiving E. coli formulation
    - Reactions range from mild: Skin rash and urticaria, to life threatening, bronchospasm, anaphylaxis
- Seen in 14% of patients receiving Erwinia asparaginase
- Reactions less common with PEG-asparaginase
    - Attachment of a PEG to a drug or therapeutic protein can mask the agent from the host's immune system
    - Decreases immunogenicity and subsequent reactions

Pancreatitis

- Develops during induction
- Incidence ~ 9-10%
- Monitor amylase and lipase once/twice weekly and symptoms
- Anorexia, nausea and vomiting, fever, jaundice, increased urination, abdominal pain, + GI bleeding
- Manage with fluids, antibiotics, analgesics, TPN
- May require dose interruption or discontinuation

Liver Toxicity/Coagulation

- Two thirds of patients have elevated LFT's starting within the first two weeks of treatment
    - Leading to the depression of hepatically-derived clotting factors resulting in excessive bleeding or clotting
- Fibrinogen level used as a marker of abnormal coagulation
    - Check before each dose
    - Maintain > 100 mg/dl with cryoprecipitate/FFP

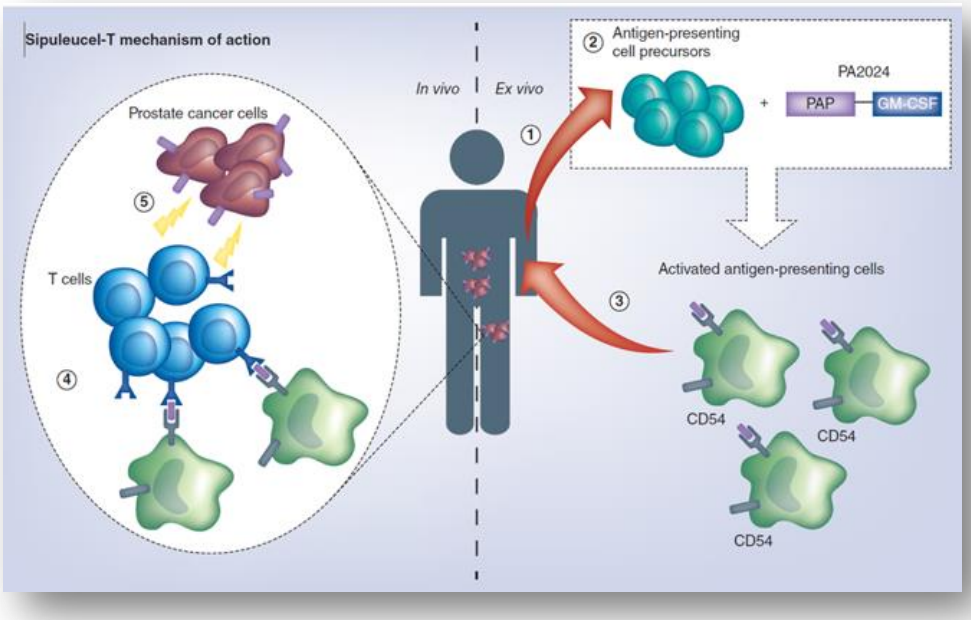
True or False: PEG asparaginase is known to have a higher risk of hypersensitivity reaction than Erwinia asparaginase due to the polyethylene glycol (PEG) polymer chain that is attached to the enzyme

A. True
B. False

Provenge (sipuleucel-T)

- FDA indication: For asymptomatic or minimally symptomatic metastatic castrate-resistant (hormone-refractory) prostate cancer
- Autologous cellular immunotherapy
- Complicated manufacturing and logistics

Mechanism of Action



Dosing

- Each dose contains ≥ 50 million autologous CD54+ cells obtained through leukapheresis activated with PAP-GM-CSF
- Administer doses at two-week intervals for a total of three doses
- If unable to receive a scheduled infusion, an additional leukapheresis procedure will be necessary prior to continuing a course of treatment

Administration

- Identity of the patient must be matched to the patient identifiers on the infusion bag and on the final product disposition notification
- Do not infuse until confirmation of product release is received from the company
- Keep the sealed infusion bag in the insulated polyurethane container inside the shipping box until ready for administration
- Prior to infusion, inspect bag for signs of leaks or damage
- Gently mix to re-suspend contents
- Infusion must begin prior to the expiration date and time: Do NOT infuse if expired
- Infuse over 60 minutes: Infuse the entire contents of the bag
- Do NOT use a cell filter for infusion
- For acute infusion reaction, interrupt or slow infusion rate
- If infusion is interrupted, keep infusion bag at room temperature; do not resume if bag is retained at room temperature for > 3 hours
- Observe patient for at least 30 minutes after infusion

Adverse Effects: Initial Infusion-Related Events Usually Present Within the First 24 Hours

- Flu-like symptoms
- Headache
- Dizziness
- Pain
- Nausea/vomiting
- Constipation
- Anemia
- Severe infusion related reaction
- Citrate toxicity

Which cells are activated with PAP-GM-CSF to create the autologous vaccine for each patient?

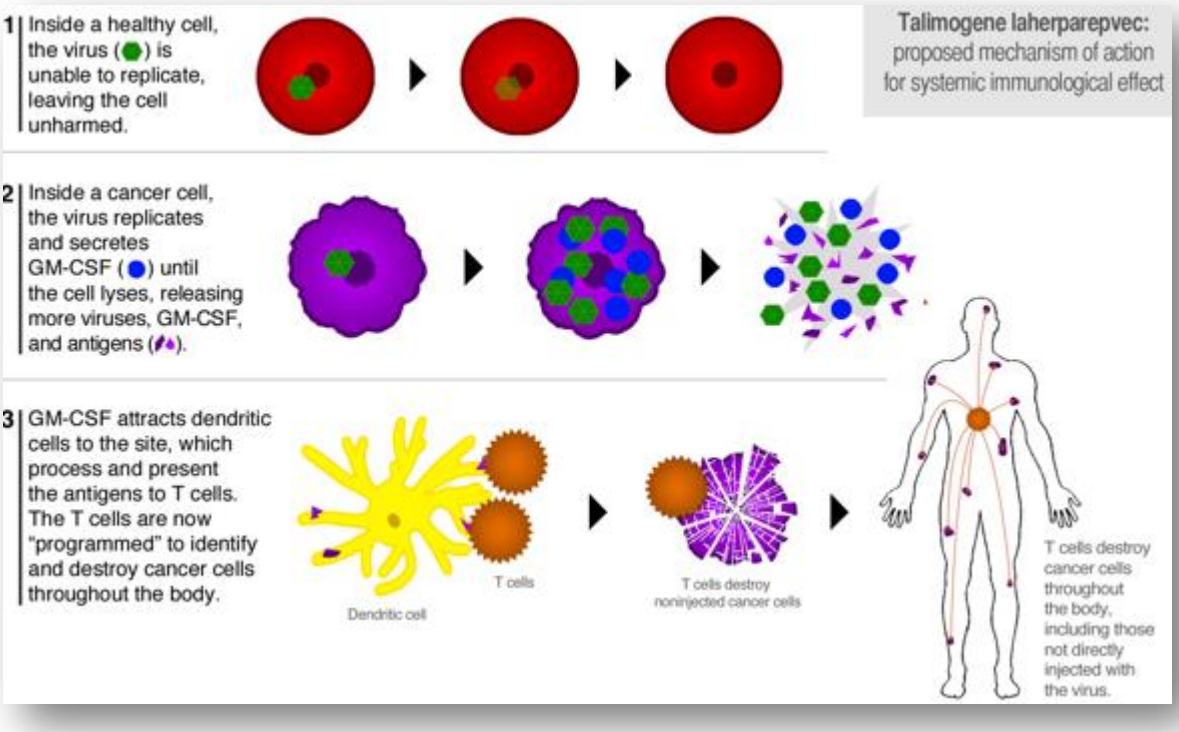
A. CD20+
B. CD30+
C. CD54+
D. CD33+
E. CD52+

_____
_____
_____
_____
_____

Imlygic (Talimogene laherparepvec, TVEC)

- Live, attenuated, genetically modified herpes simplex virus type 1 (HSV-1) oncolytic virus
- Vaccine
- Treatment (local) of unresectable cutaneous, subcutaneous, and nodal lesions in patients with melanoma recurrent after initial surgery
- FDA indication: Local treatment of unresectable cutaneous, subcutaneous, and nodal lesions in patients with melanoma recurrent after initial surgery
    - Intralesional injection into cutaneous, subcutaneous, and/or nodal lesions that are visible, palpable, or detectable by ultrasound

TVEC Mechanism of Action



Dosing

- The volume of TVEC to be injected is based on lesion size
    - > 5 cm: Inject up to 4 mL
    - > 2.5 cm to 5 cm Inject up to 2 mL
    - > 1.5 cm to 2.5 cm: Inject up to 1 mL
    - > 0.5 cm to 1.5 cm: Inject up to 0.5 mL
    - ≤ 0.5 cm: Inject up to 0.1 mL

Administration

- Clean the lesion and surrounding areas with alcohol and allow to dry
- Using a single insertion point, inject TVEC along multiple tracks as far as the needle allows within the lesion to achieve dispersion; multiple lesion points may be used if a lesion is larger than the radial reach of the needle
- Inject TVEC evenly and completely within the lesion by pulling the needle back without removing it from the lesion
- Redirect the needle as necessary while injecting the remainder of the dose; continue until the full dose is evenly and completely dispersed
- Remove the needle from the lesion slowly to avoid leakage
- Repeat steps for other lesions to be treated
- Use a new needle if the needle is completely removed from a lesion and each time a different lesion is injected
- Apply pressure with sterile gauze for at least 30 seconds after the injection is completed; swab the injection site(s) and surrounding areas with alcohol
- Change gloves, then cover lesion(s) with an absorbent pad and dry occlusive dressing, and wipe the exterior of the dressing with alcohol
- The injection site should be covered for at least the first week after each treatment or longer if the injection site is weeping or oozing and replace dressing if it falls off
- Initial visit: Inject up to 4 mL at a concentration of 10^6 (1 million) PFU/mL. Inject largest lesion(s) first; inject remaining lesion(s) based on lesion size until maximum injection volume is reached or all lesions have been treated
- Second visit (3 weeks after initial treatment): Inject up to 4 mL at a concentration of 10^8 (100 million) PFU/mL
    - Inject any new lesion(s) that have developed since initial treatment first; inject remaining lesion(s) based on lesion size until maximum injection volume is reached or all lesions have been treated
- Subsequent visits, including reinitiation (2 weeks after previous treatment): Inject up to 4 mL at a concentration of 10^8 (100 million) PFU/mL
    - Inject any new lesion(s) that have developed since previous treatment first; inject remaining lesion(s) based on lesion size until maximum injection volume is reached or all lesions have been treated

Adverse Effects

- Flu-like symptoms
- Headache
- Dizziness
- Nausea/vomiting
- Diarrhea/constipation
- Pain at injection site
- Pain in extremity

Miscellaneous

- Immunocompromised or pregnant should not prepare or administer TVEC and should not come into direct contact with injection sites, dressings, or body fluids of treated patients
- Wear personal protective equipment
- Herpetic infections have been reported disseminated herpetic infection may occur in
- If herpes-like lesions develop, follow standard practice to prevent viral transmission
    - Contact a health care provider for evaluation
- TVEC is sensitive to antiviral therapy, consider the risks and benefits of treatment prior to administering antiviral agents

True or False: There is a lifetime maximum amount of TVEC that a patient can receive

A. True
B. False

Miscellaneous Chemotherapeutic Agents

Miscellaneous Agents

Leukemia/Lymphoma

APL Drugs
- ATRA
- Arsenic Trioxide

IDH1 Inhibitor
- Ivosidenib

IDH2 Inhibitor
- Enasidenib

BCL-2 Inhibitor
- Venetoclax

HDAC Inhibitors
- Vorinostat
- Belinostat
- Romidepsin

MM

IMIDs
- Thalidomide
- Lenalidomide
- Pomalidomide

Proteasome Inhibitors
- Bortezomib
- Carfilzomib
- Ixazomib

HDAC Inhibitor
- Panobinostat

Solid Tumors

mTOR Inhibitors
- Everolimus
- Temsirolimus

PI-3 Kinase Inhibitor
- Copanlisib
- Idelalisib
- Apelisib

CDK Inhibitors
- Palbociclib
- Ribociclib
- Abemaciclib

PARP Inhibitors
- Olaparib
- Rucaparib
- Niraparib
- Talazoparib

Hedgehog Pathway Inhibitors
- Vismodegib
- Sonidegib

Acute Promyelocytic Leukemia (APL) Drugs
- Tretinoin (all trans retinoic acid – ATRA)
- Trisenox (arsenic trioxide)

Tretinoin (all trans retinoic acid – ATRA)
- Indication
  - APL induction, consolidation, maintenance
- Dose, route and administration
  - 45 mg/m2/day PO in two equally divided doses
  - Take with a meal
  - Do not crush capsule
- Miscellaneous
  - t15;17 or PML-RARα must be present in bone marrow cytogenetics
  - Protect from light
  - Handling precaution: Do not handle medication or bodily fluids without gloves
- Dose Adjustments
  - APL differentiation syndrome

- Box warning
    - APL differentiation syndrome, leukocytosis, pregnancy
- Dosage and cost
    - Capsule: 10 mg
    - Each capsule: $30

Tretinoin Common Toxicities

- Fever 83%
- Headache 86%
- Dry skin 77%
- Dry mucous membranes 77%
- Malaise 66%
- Hemorrhage 60%
- Dyspnea 60%
- Infection 58%
- Nausea/vomiting 57%
- Peripheral edema 52%
- Leukocytosis 40%DIC 26%
- GI hemorrhage 34%
- Hypercholesterolemia < 60%
- Hypertriglyceridemia < 60%
- Transaminitis 50-60%
- Otalgia 23%
- Dizziness 20%
- Visual disturbances 17%
- Skin changes 14%

Tretinoin: Unique Toxicities

- Differentiation Syndrome
    - Release of intracellular cytokines from APL cells (25% of patients)
    - Fever, dyspnea, hypotension, edema, acute respiratory distress, weight gain, pleural and/or pericardial infiltrates, musculoskeletal pain, hyperbilirubinemia, hepatic and/or renal failure
    - Treat with steroids immediately
        - Dexamethasone 10mg IV q12h for 3 days
            - 30% mortality without therapy
            - $\leq$1% with therapy
- Pseudotumor Cerebri
    - $\leq$1% incidence
    - Papilledema, headache, nausea, vomiting, visual disturbances, intracranial noises, or pulsatile tinnitus
    - Increased incidence with concurrent tetracycline use
    - Treat with steroids
        - Prednisone 0.5 mg/kg daily

Patient Care Considerations

- Educate patients to report all side effects, especially APL differentiation syndrome, promptly
- Monitor CBC with differential, liver function, coagulation profile, cholesterol and triglyceride levels
- Avoid medications and supplements that contain vitamin A or vitamin A derivatives
- Handling precautions – do not handle medication or bodily fluids without gloves
- Avoid in 1st trimester in pregnancy
- Monitoring pregnancy status (1 week prior to treatment and monthly during treatment)
- Recommended to use two reliable forms of contraception during and for 1 month after tretinoin discontinuation, unless abstinence is the chosen method
- Avoid breastfeeding starting one week prior to and during treatment

Trisenox (arsenic trioxide, ATO)

- Indication
  - APL induction
  - APL relapsed or refractory
- Dose, route and administration
  - 0.15 mg/kg/day IV once daily
  - Administer over 2 hours if acute vasomotor reactions: Flushing, sweating, tachycardia
  - Infuse over 4 hours
- Miscellaneous
  - Prior to administration, verify K > 4 and Mg > 1.8
    - Obtain EKG prior and frequently during treatment
  - Two different concentration solution are available: 10 mg /10 mL or 12 mg / 6 mL
  - Central venous catheter is not required
  - Administer hydroxyurea if WBC > 10,000
- Dose adjustments
  - Renal; hepatotoxicity during treatment; WBC <1000 or platelets <50K; APL differentiation syndrome; QTc prolongation; >Gr 2 nonhematologic

Trisenox Common Toxicities

- Nausea 75%
- Fatigue 63%
- Cough 65%
- Fever 63%
- Headache 60%
- Abdominal pain 58%
- Tachycardia 55%
- Diarrhea 53%
- Dyspnea 53%
- Hypokalemia 50%
- Hyperglycemia 45%
- Insomnia 43%
- Dermatitis 43%
- Arthralgia/myalgia 25-33%
- Leukocytosis 50% / >Gr 3 3%)
- Chest pain 25%Hypotension 25%
- Epistaxis 25%
- Pleural effusion 20%
- Depression 20%
- Transaminitis 13-20%
- Pain at injection site 20%
- Herpes simplex infection 13%
- Blurred vision 10%
- Hyperpigmentation 8%
- Renal failure syndrome 8%
- Otalgia 8%

Toxicities Requiring Modifications

- Differentiation syndrome: Incidence up to 31%
  - Treat with steroids immediately: Dexamethasone 10mg IV q 12h for 3 days
  - Dose reduce 50%, 0.075 mg/kg/day, for 7 days then up titrate
- QTc prolongation: 40% > 500 msec (torsades de pointes 3%)
  - Monitor QTc: Hold arsenic trioxide if QTc > 500 msec
    - Restart when QTc: 450 for men; 460 for women
  - Electrolyte abnormalities 45-50% (replace for K <1.8; Mg <4)
  - Dose reduce 50%, 0.075 mg/kg/day, for 7 days then up titrate
- Encephalopathy $\leq$ 1%
  - Monitor for thiamine deficiency: Replace with IV thiamine
- Leukocytosis: WBC > 10,000/mm3
  - Administer hydroxyurea until WBC < 10,000/mm3
  - Neutropenia: < 1000/mm3 and thrombocytopenia: < 50,000/mm3
    - Dose reduction required
  - Second malignancy

Patient Care Considerations

- Educate patients to report all side effects, especially APL differentiation syndrome promptly
- Monitor CBC with differential, renal function, hepatic function, glucose, and coagulation profile
- Monitor EKG before and during therapy for prolonged QT interval
- Do not administer with other QTc prolonging medications
- Do not start or discontinue meds without notifying provider
- Avoid in pregnancy
- Females should use contraceptives during and for six months after last arsenic trioxide dose
- Males with female partners should use contraceptives, even after vasectomy, during and for three months after last arsenic trioxide dose
- Avoid breastfeeding during and for two weeks after last arsenic trioxide treatment

Which one of the following should be monitored in a patient receiving arsenic trioxide?

A. Daily electrolytes (e.g., K+, Mg++)
B. EKG - QTc interval (at least weekly)
C. Daily CBC
D. All the above

IDH Inhibitor

- TIBSOVO (ivosidenib)

TIBSOVO (ivosidenib)

- Mechanism: Inhibits mutant IDH1 enzyme (7% to 14%)
- Indication: Acute myeloid leukemia
    - Newly diagnosed
        - Age ≥ 75 years or if comorbidities that preclude intensive induction chemotherapy
    - Relapse/refractory
        - Susceptible IDH1 mutation detected by approved test
- Dosing and administration
    - PO – 500mg PO daily: > 6 months
    - Administer with or without food: No high fat meals
- Dose adjustments
    - Toxicity: Renal and hepatic insufficiency, not studied
- Box warnings
    - Differentiation syndrome

Ivosidenib – Common Toxicities

- Diarrhea: 34-61%
- Fatigue: 39-50%
- Edema: 32-43%
- Arthralgia: 32-36%
- Myalgia: 18-25%
- Dyspnea: 29% to 33%
- Skin rash: 14-26%
- Fever: 23%
- Dizziness: 21%
- Tumor lysis syndrome (TLS): 8%; > grade 3/4: 6%
- Increased serum creatinine: 23-29%
- Increased uric acid: 29-32%
- Decreased K: 31-43%
- Decreased Na: 39%
- Decreased Mg: 25-38%
- Decreased serum Ca: 25%
- Decreased Phos: 21-25%
- Increased AST: 27-29%
- Increased ALT: 14-15%

Ivosidenib Toxicities Requiring Dose Modifications

- Differentiation Syndrome: 19-25%; grade 3/4: 11-13%
  - Occurs from Day 1 to 3 months. Treat with steroids immediately
    - Dexamethasone: 10mg IV q 12h for 3 days
- QT Prolongation: 21-26% and ventricular arrythmias: < 1%
  - Interrupt ivosidenib treatment if QTc increases to > 480 msec but < 500 msec
    - Restart at 500 mg daily after the QTc interval returns to ≤ 480 msec
  - If QTc increases to >500 msec, interrupt treatment
  - Restart at 250 mg daily after the QTc interval returns to ≤ 480 msec
    - Monitor ECGs at least weekly for 2 weeks
    - Permanently discontinue if there is QTc interval prolongation with signs or symptoms of life-threatening arrhythmia
- Non-infectious leukocytosis: WBC >25,000/mm^3 or absolute WBC increase from baseline of >15,000/mm^3, 36-38%; grade 3/4: 7-8%
  - Initiate cytoreduction therapy: Hydroxyurea, or leukapheresis, if clinically indicated
- Grade 3 or higher toxicity
  - Interrupt ivosidenib treatment until resolves to ≤ grade 2
  - Resume ivosidenib at 250 mg daily; may increase to 500 mg daily if toxicity resolves to ≤ grade 1
  - If ≥ grade 3 toxicity recurs, discontinue
- Guillain-Barré syndrome: < 1%, permanently discontinue

IDHI2 Inhibitor: Idhifa (enasidenib)

Idhifa (enasidenib): Common Toxicities

- Nausea: 50%
- Diarrhea: 43%
- Decrease appetite: 34%
- Vomiting: 34%
- Acute respiratory distress: ≤ 10%
- Pulmonary edema: ≤ 10%
- Decreased Ca: 74%
- Decreased K: 41%
- Increased serum bilirubin: 81%
- Abnormal phosphorus levels: 27%; grade 3/4: 8%
- TLS: 6%

Enasidenib Toxicities Requiring Modifications

- Differentiation syndrome: 14%
  - Occurs from Day 1 to 5 months
  - Treat with steroids immediately: Dexamethasone 10mg IV q 12h for 3 days
- Noninfectious leukocytosis: WBC >30,000/mm^3, 12%; grade 3/4: 6%
  - Initiate cytoreduction therapy: Hydroxyurea
  - Hold if leukocytosis is not improved, then resume 100 mg daily when WBC <30,000/mm^3

- Hepatotoxicity during treatment: Up to 81%
    - Bilirubin > 3 times ULN for ≥ 2 weeks without elevated transaminases or other hepatic disorders
        - Reduce dose to 50 mg daily
        - Resume at 100 mg daily if bilirubin resolves to <2 times ULN
- Grade 3 or higher toxicity (considered to be treatment-related)
    - Hold until toxicity improves to ≤ grade 2
    - Resume at 50 mg daily; may increase to 100 mg daily if toxicity resolves to ≤ grade 1
- If ≥ grade 3 toxicity recurs, discontinue enasidenib

IDH1 and IDH2 Inhibitors: Patient Care Considerations

- IDH1 or IDH2 mutation status prior to treatment initiation
- CBC with differential, LFTs, and blood chemistries
    - Baseline and every 2 weeks for at least the first 3 months
- Monitor for signs/symptoms of differentiation syndrome
- Monitor for tumor lysis syndrome
- Pregnancy test: Prior to treatment in females of reproductive potential
    - Effective contraception should be used during therapy and ≥ 2 months after the last dose
    - Male patients with female partners of reproductive potential should also use effective contraception during therapy and for at least 2 months after the last dose
- Do not breastfeed for at least 2 months after the last dose
- Only available at authorized specialty pharmacies

BCL-2 Inhibitor

- Venclexta (venetoclax)

Venclexta (venetoclax)

- Mechanism: Cytotoxic activity in tumor cells which overexpress BCL-2
    - Venetoclax selectively inhibits and binds directly to the BCL-2 protein, displacing pro-apoptotic proteins and restoring the apoptotic process
- Indications
    - Chronic lymphocytic leukemia(CLL)/small lymphocytic lymphoma
        - Monotherapy and in combination treatment
    - Newly diagnosed AML
        - Combination treatment: In combination with azacitidine, decitabine, or low dose cytarabine
    - Age ≥ 75 years or with comorbidities that do not allow use of intensive induction chemotherapy
    - No box warning

- Tumor lysis syndrome (TLS)
    - Administer prophylactic hydration and anti-hyperuricemics prior to the first dose
    - WBC should be < 25,000/mm^3 prior to initiation of venetoclax
        - Cytoreduction prior to treatment may be required

Dosing Varies by Indication

	CLL	AML
Dosing	Monotherapy • Week 1: 20 mg daily • Week 2: 50 mg daily • Week 3: 100 mg daily • Week 4: 200 mg daily • Week 5: 400 mg daily	Combination therapy • Day 1: 100 mg daily • Day 2: 200 mg daily • Day 3: 400 mg daily • Day 4: 600 mg daily, if needed

Combination Therapy	Venetoclax in combination until disease progression or unacceptable toxicity:
	• With obinutuzumab: Cycle 1, day1
	  ○ Initiate venetoclax increase on cycle one day 22 of 28-day cycle
	  ○ Continue until the end of cycle 12
	• With rituximab: Begin rituximab after increasing complete on week 5 and thereafter
	  ○ 400 mg daily
	  ○ Continue for up to 24 months
		Venetoclax in combination until disease progression or unacceptable toxicity
		• With azacitidine or decitabine
		  ○ Max 400 mg daily
		• With low-dose cytarabine
		  ○ Max 600 mg daily

Dose Adjustment	Concomitant strong or moderate CYP3A inhibitors or P-gp inhibitors • >75% for strong CYP3A inhibitors • >50% for moderate CYP3A inhibitors or P-gp inhibitors Severe hepatic impairment, Child-Pugh class C: Reduce dose by 50%	

Venclexta Drug-Drug Interactions

- p inhibitors
  - Amiodarone, carvedilol, clarithromycin, dronedarone, itraconazole, lapatinib, lopinavir and ritonavir, propafenone, quinidine, ranolazine, ritonavir, saquinavir and ritonavir, telaprevir, tipranavir and ritonavir, verapamil
- Moderate CYP3A inhibitors
  - Aprepitant, ciprofloxacin, conivaptan, crizotinib, cyclosporine, diltiazem, dronedarone, erythromycin, fluconazole, fluvoxamine, imatinib, tofisopam, verapamil
- Strong CYP3A inhibitors
  - Boceprevir, cobicistat, danoprevir and ritonavir, elvitegravir and ritonavir, grapefruit juice, indinavir and ritonavir, itraconazole, ketoconazole, lopinavir and ritonavir, paritaprevir and ritonavir and (ombitasvir and/or dasabuvir), posaconazole*, ritonavir, saquinavir and ritonavir, telaprevir, tipranavir and ritonavir, telithromycin, troleandomycin, voriconazole
- Moderate CYP3A4 inducers
  - Bosentan, efavirenz, etravirine, phenobarbital, primidone
- Strong CYP3A4 inducers
  - Apalutamide
  - Carbamazepine
  - Enzalutamide
  - Mitotane
  - Phenytoin
  - Rifampin
  - St. John's wort

Venclexta Toxicities

- Increased AST: 53%
- Diarrhea: 43%
- Nausea: 42%
- Upper respiratory tract infection: 36%
- Fatigue: 32%
- Musculoskeletal pain: 29%
- Edema: 22%
- Cough: 22%
- Fever: 18%
- Headache: 18%
- Abdominal pain: 18%
- Skin rash: 18%
- Dizziness: 14%
- Pneumonia: 14%
- Febrile neutropenia: 6%
  - ≥ Gr 3: 6%
- Leukopenia: 89%
  - > Gr 3/4: 42%
- Neutropenia: 50% to 87%
  - Gr 3: 45-63%
  - Gr 4: 33%
- Lymphocytopenia: 11-74%
  - Gr 3: 7-40%; Gr 4: 9%
- Anemia: 33-71%
  - ≥ Gr 3: 18-26%
- Thrombocytopenia: 29-64%
  - Gr 3: 20-31%; Gr 4: 15%)
- Tumor lysis syndrome (TLS)
  - 2-3-week ramp-up phase 13%
  - 5-week ramp-up phase: 2%
- Hyperuricemia: 10%
- Hypocalcemia: 16-87%
- Hyperkalemia: 17-59%
- Hypophosphatemia: 45%
- Hyponatremia: 40%
- Hyperglycemia: 67%

Patient Care Considerations

- Determine whether venetoclax should initiated in inpatient or outpatient setting
- Review patient's home medications for drug interactions
- Order appropriate venetoclax dosage and supply based on ramp-up dosing schedule
    - Available as 10 mg, 50 mg, and 100 mg tablets
    - NOTE: The "CLL/SLL Starting Pack" should not be used for AML patients
- Start allopurinol or other xanthine oxidase inhibitor at least 2-3 days before first dose
- Instruct patient to begin oral hydration (1.5-2 L/day) 2 days before the first dose
- Contact patient PRIOR to scheduled treatment appointment to verify the following:
    - Patient received venetoclax supply
    - Patient stopped taking any interacting medications as instructed (if applicable)
    - Patient started taking allopurinol and oral hydration as instructed
    - Patient will bring venetoclax and a meal with them to clinic appointment

HDAC Inhibitors

- Zolinza (vorinostat)
- Beleodaq (belinostat)
- Isodax (romidepsin)

Zolinza (vorinostat)

- Indication
    - Cutaneous T-cell lymphoma
- Route of Administration
    - PO Take with food
- Dosing and schedule
    - 400 mg daily
- Dose adjustment
    - Hepatic
    - Grade 4 anemia or thrombocytopenia
- Box warning
    - None
- Dosage forms and cost
    - 100 mg capsule
    - $150 per capsule

Beleodaq (belinostat)

- Indication
  - Peripheral T-cell lymphoma
- Route of administration
  - IV 30-minute infusion using 0.22-micron inline filter
- Dosing and schedule
  - 1000 mg/m2 on D1-5: 21-day cycle
- Dose adjustment
  - UGT1A1*28: 750 mg/m2
  - Platelets < 25k
  - Absolute neutrophil count (ANC) < 500
  - Any > grade 3 nonhematologic toxicity
- Box warning
  - None
- Dosage forms and cost
  - 500 mg vial
  - $2437 per vial

Isodax (romidepsin)

- Indication
  - Cutaneous T-cell lymphoma
  - Peripheral T-cell lymphoma
- Route of administration
  - IV over four hours
- Dosing and schedule
  - 14 mg/m^2 on day 1, 8, 15, of a 28-day cycle
- Dose adjustment
  - Hepatic
  - Febrile neutropenia
  - Any > grade 3 nonhematologic toxicity
- Box warning
  - None
- Dosage and cost
  - 10 mg vial
  - $3838 per vial

Side Effects	Vorinostat	Belinostat	Romidepsin
Hyperglycemia	8-69%	-	< 52%
Peripheral edema	13%	20%	6-10%
Proteinuria	51%	0%	0%
Increased serum creatinine	16-47%	> 2%	-
Transaminitis	-	-	2-28%
QTc prolongation	3-4%	11%/≥ Gr 3 -4%	< 10%
VTE – DVT/PE	1%/5%	0%	< 10%
Fever	11%	35%	20-47%
Fatigue	52%	37%	77%
Skin rash	-	20%	-
Squamous cell carcinoma	3.5%	-	-
Dyspnea	-	22%	13-21%
Infection	< 1%	2-3%	< 54%
Alopecia	19%	-	-
Diarrhea	52%	23%	12-40%
Nausea	41%	42%	56-86%
Vomiting	15%	29%	34-52%
Anemia	14%/≥ Gr 3- 2.3%	32%/11%	< 72%/ ≥ Gr 3- 11-28%
Thrombocytopenia	26%/≥ Gr 3- 3%	16%/7%	< 66%/ ≥ Gr 3- 24-36%
Dizziness	15%	29%	-
Hypotension	10%	10%/≥ Gr 3 – 3%	7-23%
Headaches	12%	15%	15-34%
Injection site pain	-	14%	-
Electrolyte abnormalities	-	12% (K)	< 52% (Mg, Ca, K, Na, Phos, uric acid, albumin

Vorinostat: Patient Care Considerations

- Monitor CBC and chemistries every two weeks for the first two months of therapy, then monthly
- Monitor hepatic function
- Monitor for signs of dehydration and treat all pre-existing electrolyte abnormalities
- Handling precautions: Do not handle medication or bodily fluids without gloves
- Females should use contraceptives for six months after last vorinostat dose
- Males with female partners should use contraceptives for three months after last vorinostat dose
- Avoid breastfeeding during and for one week after last vorinostat dose

Belinostat: Patient Care Considerations

- Monitor CBC and hepatic and renal function
- Monitor for signs/symptoms of dehydration and correct all pre-existing electrolyte abnormalities
- Monitor for skin toxicity
- Monitor liver function tests before treatment and before the start of each subsequent cycle
- Genetic counseling - Homozygous for the UGT1A1*28 allele
- Females should use contraceptives for six months after last belinostat dose
- Males with female partners should use contraceptives for three months after last belinostat dose
- Avoid breastfeeding during and for two weeks after last belinostat dose

Romidepsin: Patient Care Considerations

- Monitor CBC and electrolytes (Ca, Mg, K, Phos)
    - Ensure K and Mg are normal before administering
- Consider monitoring EKG in patients with:
    - History of cardiovascular disease (also congenital long QT syndrome) and/or are taking concurrent medications that can prolong QT interval
- Risk for increased toxicities with concurrent use with strong CYP3A4 inhibitors
- Avoid use with rifampin and strong CYP3A4 inducers – decreased efficacy
- Handling precautions: Do not handle bodily fluids without gloves
- Monitor for infections
- Pregnancy test seven days prior to romidepsin treatment
- Females should use contraceptives for one month after last romidepsin dose
- Males with female partners should use contraceptives for 1 months after last romidepsin dose
- Avoid breastfeeding during and for 1 week after last romidepsin dose

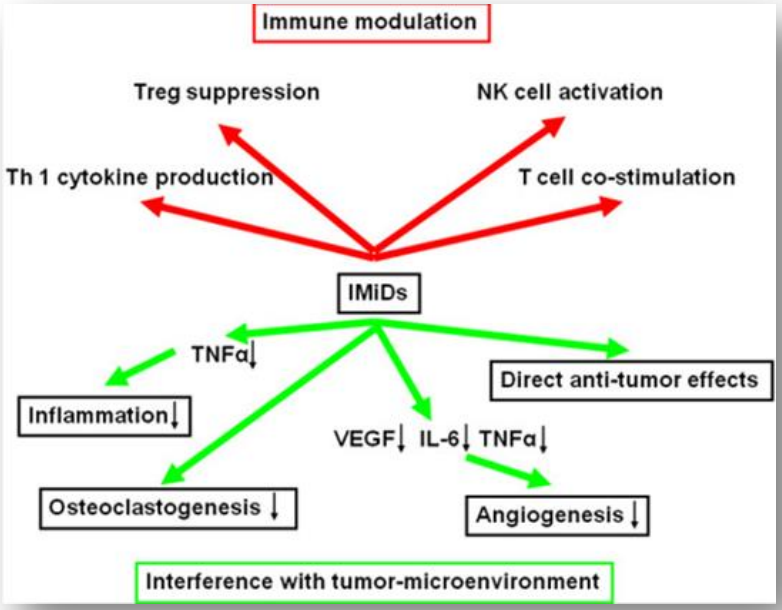
Immunomodulatory Agents: IMiDs: Immunomodulatory imide drugs

- Thalidomide (thalidomide)
- Lenalidomide (enalidomide)
- Pomalidomide (pomalidomide)

Risk Evaluation Mitigation Strategy (REMS)

- Patient and prescriber MUST complete monthly survey before drug can be dispensed
- Patient, pharmacy, and physician must all be enrolled in Thalomid, Revlimid, or Pomalyst REMS program
    - Celgeneriskmanagement.com 1-888-423-5436
- Women of childbearing potential must have pregnancy test monthly

Mechanism of Action



Thalidomide

- Indication
  - Multiple myeloma (MM)
    - New diagnosis
    - Relapse/refractory
  - Also use in non-malignancy
- Administration
  - Oral: Bedtime, > 1hr after evening meal
  - Swallow capsules whole with water
- Dosing in combination with dexamethasone
  - 200 mg daily
- Dosing adjustments
  - ANC ≤750/mm3
  - Dermatologic reactions
  - Grade 3 or 4 adverse events
  - Non-hematologic toxicity
- Box warning
  - Thromboembolic events
  - Pregnancy
- Dosage forms and cost
  - Capsule: 50, 100, 150, 200 mg
  - $379 each capsule

Lenalidomide

- Indications
  - MM
    - New diagnosis
    - Relapse/refractory
  - Myelodysplastic syndrome (MDS)
  - Lymphoma
- Administration
  - Oral with or without food
  - Swallow capsule whole
- Dosing in combination with dexamethasone
  - 25 mg daily on days 1 to 21 days of a 28-day cycle
- Dosing adjustments
  - Renal impairment: Creatinine clearance < 60 mL/min
  - Hematologic
  - Non-hematologic toxicity
- Box warning
  - Thromboembolic events
  - Pregnancy
- Dosage forms and cost
  - Capsule: 2.5, 5, 10, 15, 20, 25 mg
  - $1042 each capsule

Pomalidomide

- Indication
  - MM
    - New diagnosis
    - Relapse/refractory
- Administration
  - Oral without regard to meals
  - Swallow capsule whole with water
- Dosing in combination with dexamethasone
  - 4 mg daily on days 1 to 21 of 28-day cycles
- Dosing adjustments
  - Strong CYP1A2 Inhibitors
  - Hepatic impairment
  - Hematologic
  - Non-hematologic toxicity
- Box warning
  - Thromboembolic events
  - Pregnancy
- Dosage forms and cost
  - Capsule: 1, 2, 3, 4 mg
  - $1042 each capsule

Other Indications

- Thalidomide
  - Leprosy
  - AIDs-related aphthous stomatitis, chronic graft-versus-host disease, amyloidosis, Waldenström macroglobulinemia
- Lenalidomide
  - Low or Intermediate 1-risk MDS (del 5q)
  - Mantle cell lymphoma (MCL)
  - Marginal zone lymphoma
  - Follicular lymphoma
  - Chronic lymphocytic leukemia (relapsed/refractory), diffuse large B cell lymphoma, amyloidosis
- Pomalidomide
  - Kaposi sarcoma

Side Effects	Thalidomide	Lenalidomide	Pomalidomide
Drowsiness	≤ 38%	20%	-
Dizziness	≤ 4%	20%	22%
Headache	≤ 13%	9-20%	15%
Peripheral neuropathy	≤ 10%	5-10%	22%
Constipation	≤ 4%	13-24%	22%
Diarrhea	-	39-49%	35%
Fatigue	≤ 8%	11-34%	< 58%
Myalgias	Not defined	7-99%	12%
Fever	-	21-23%	23%
Thromboembolic events	3-4%/22.5%	3-6%/26%	4%/17%
Peripheral edema	≤ 4%	16-20%	25%
URI	Not defined	11-15%	37%
Increased serum creatinine	-	Not defined	19%
Rash	≤ 4%	8-36%	21%
Neutropenia	Not defined	49-61%/ ≥ Gr 3-43-54%	53%/ ≥ Gr 3-48%
Thrombocytopenia	Not defined	24-62%/ ≥ GR 3-13-50%	26%/≥ Gr 3-22%

IMiDs: With steroids and other agents and Venous Thromboembolism (VTE) Risk

- Thalidomide, lenalidomide or pomalidomide monotherapy: VTE risk < 5%
- Thalidomide or lenalidomide plus low-dose dexamethasone: VTE risk is 12-14%
- Thalidomide or lenalidomide plus high-dose dexamethasone: VTE risk > 20%
  - Pomalidomide plus high-dose dexamethasone is slightly less: VTE risk 17%

VTE Risk and Anticoagulation

- Low Risk: Aspirin 81mg vs no anticoagulation required
- Standard Risk: Aspirin > warfarin vs low-molecular-weight heparin (LMWH)
- High Risk: Warfarin vs LMWH
- Direct Oral Anticoagulants (DOACs): Limited data with prophylaxis dosing

Anticoagulation

- Decrease VTE risk to $\leq$ 10%
- Continue as long as receiving thalidomide or lenalidomide

IMiDs: MM

Patient Care Considerations

- Notify provider if skin rash develops
- Monitor for s/s of thromboembolic events
- Do not donate blood during treatment or for 1 month after stopping treatment
- Precautions: do not handle medication or bodily fluids without gloves
- Education about risk for birth defects with males and females
    - Need to use double barrier methods of contraception
- Thalidomide specific
    - Bowel regimen to prevent constipation
    - Administer at bedtime
- Lenalidomide specific
    - Monitor CBC (hold for ANC <1000 and/or platelets < 30,000)
    - Increased risk of secondary malignancy (e.g., AML)
- Pomalidomide specific
    - Monitor CBC, LFTs, and serum creatinine
    - Liver metabolism CYP1A2 and CYP3A4: Need to watch for drug interactions
    - Smoking may also reduce efficacy of pomalidomide

Which one of the following is not true regarding thalidomide and/or lenalidomide?

A. Patient and provider must enroll in the REMS programs
B. Warfarin (INR goal = 2-3) is appropriate Venous thromboembolism (VTE) prophylaxis for a patient receiving bortezomib, thalidomide and dexamethasone
C. Significant peripheral neuropathy can occur from treatment
D. All patients receiving lenalidomide monotherapy require VTE prophylaxis

Proteasome Inhibitors

- Velcade (bortezomib)
- Kyprolis (carfilzomib)
- Ninlaro (Ixazomib)

Velcade (bortezomib)

- Indication
  - New diagnosis
  - Relapsed or refractory MM or mantle cell lymphoma (MCL)
- Type of inhibitor
  - Reversible
- Route of administration
  - IVP 3-5 secs
  - Subcutaneous injection: Abdomen or thigh
- Dosing and scheduling
  - 1.3 mg/m2 range 1 to 1.5 mg/m2 on D1, 4, 8, and 11 of 21 day cycle
  - Doses separated by > 72 hrs
- Dose Adjustments
  - Hepatic
  - Platelets <30k
  - ANC <750
  - Any > grade 3 nonhematologic toxicity
- Dosage and cost
  - 3.5 mg vial
  - $1924

Kyprolis (carfilzomib)

- Indication
  - Relapse/refractory MM
- Type of inhibitor
  - Irreversible
- Route of Administration
  - IV 10 to 30 minutes
- Dosing and Schedule
  - C1: 20 mg/m2
  - C2-CX: 27 alternate 56 or 70 mg/m2 on D1,2,8,9,15, and 16 of 28 day cycle
    - Hydrate prior and after

Ninlaro (ixazomib)

- Indication
  - After one line of treatment
- Type of inhibitor
  - PO: > 1h prior to and > 2hr after meals
- Dosing and schedule
  - 4 mg weekly on D1,8, and 15 of a 28-day cycle
- Dose Adjustments
  - Hepatic; renal
  - Platelets < 30k
  - ANC <500
  - Any > grade 3 nonhematologic toxicity
- Dosage form and cost
  - Capsule: 2, 3, 4, mg
  - $4089

Side Effects	Bortezomib	Carfilzomib	Ixazomib
Fatigue	7-52%	40-52%	-
Neutropenia	5-27%	19-21%	67%
Anemia	12-23%	42-49%	-
Thrombocytopenia	Up to 52%	32-54%	78%
Peripheral neuropathy	IV: 35-54%/SC:37%	< 20%/≥ Gr 3 – 1%	28%
Neuralgia	23%	-	-
Hypotension	8-9%	-	-
Hypertension	6%	15-42%	-
Chest pain	-	3-21%	-
Peripheral edema	7%	20%	25%
Back pain	1-17%	12-21%	21%
Upper respiratory infection	11-15%	19-21%	21%
Fever	8-23%	30-58%	-
Skin rash	12-28%	-	-
Dyspnea	15-23%	34-58%	-
Nausea	16-52%	35-54%	26%
Vomiting	9-29%	17-33%	22%
Diarrhea	19-52%	25-27%	42%
Constipation	18-34%	21%	34%
Dizziness	10-18%	13%	-
Injection site reaction	IV 5%, SC 6%	-	-
Hepatotoxicity	Case reports	-	<1%
Increases serum creatinine	-	17-25%	-
Renal insufficiency	-	10%	-
Headache	14-26%	24-33%	-

Eye disease	-	-	26%
Blurred vision	-	<10%	6%

Which sites are preferred for bortezomib administration?

A. Gluteal and abdomen (rotating)
B. Thigh and abdomen (rotating)
C. Deltoid and thigh (rotating)
D. Abdomen (rotating)

Bortezomib: Patient Care Considerations

- Monitor CBC and hepatic function
- Monitor blood pressure and EKG/cardiac function
- Assess for peripheral neuropathy at baseline and every visit
- For subcutaneous injection, rotate injection sites
- Do not take or start new medications with consulting provider
    - Avoid CYP3A4 inhibitors or inducers and grapefruit juice
- Avoid green tea and green tea extracts ascorbic acid (do not 12 hrs before or after) – reduce efficacy
- Females - use contraceptives for 7 months after last bortezomib dose
- Males with female partners should use contraceptives for 4 months after last bortezomib dose
- Avoid breastfeeding during and for 2 months after last bortezomib dose

Carfilzomib: Patient Care Considerations

- Monitor CBC and hepatic and renal function
- Monitor blood pressure and EKG/cardiac function
    - Hypertension should be controlled prior to beginning carfilzomib and monitored continually during treatment
- Infusion-related reaction (within 24 hours of infusion)
- Use a lower starting dose with mild to moderate hepatic impairment
- Females should use contraceptives for 6 months after last bortezomib dose
- Males with female partners should use contraceptives for 3 months after last bortezomib dose
- Avoid breastfeeding during and for 2 weeks after last bortezomib dose

Ixazomib: Patient Care Considerations

- Monitor CBC and hepatic and renal function
- Monitor gastrointestinal and dermatologic toxicity
- Assess for peripheral neuropathy at baseline and every visit
- Monitor for peripheral edema
- If a dose is missed, then administer only if the next scheduled dose is $\geq$72 hours away
- If vomiting occurs, do not repeat the dose

- Handling precautions – do not handle medication without gloves
    - Avoid skin or eye exposure (wash or flush immediately)
    - Females should use contraceptives for at least 90 days after last dose
    - Avoid breastfeeding during and for 90 days after last ixazomib dose

HDAC Inhibitors
- Zolinza (vorinostat)
- Beleodaq (belinostat)
- Istodax (romidepsin)
- Panobinostat (farydak)

Panobinostat (farydak)

Indication
- Treatment of multiple myeloma in combination with bortezomib and dexamethasone in patients who have received at least two prior regimens, including bortezomib and an immunomodulatory agent

Dosing and administration
- 20mg PO once every other day, Monday, Wednesday, and Friday, each week during weeks 1 and 2 of a 21-day cycle
    - In combination with bortezomib and dexamethasone for up to 8 cycles

Administration
- With or without food.
- Antiemetic required
    - Moderate emetic potential

Dosing adjustments
- Mild to moderate hepatic insufficiency
- Platelets < 30k
- ANC < 500
- Any > grade 3 nonhematologic toxicity
- Concomitant with CYP2D6 substrates
- Strong CYP3A4 inducers or inhibitors

Box Warning
- Severe diarrhea
- Cardiac toxicities
    - Ischemia, severe arrhythmias, EKG changes

Dosage Forms and Cost
- Capsule: 10, 15, 20 mg
- $2137

Drug-Drug Interactions

- Avoid concomitant use with strong CYP3A4 inhibitors
    - If cannot avoid concomitant use, reduce panobinostat dose
- If used with a strong CYP3A4 inhibitor
    - Reduce the starting dose to 10mg
- Avoid concomitant use with strong CYP3A4 inducers
- Avoid CYP2D6 substrates
- Consider antiemetics to prevent nausea and vomiting
    - Note QTc interval prior to long-acting antiemetic

Panobinostat Toxicities

- Diarrhea: 68%/≥ grade 3: 25%
- Nausea: 36%/≥ grade 3: 6%
- Vomiting: 26%/≥ grade 3: 7%
- Myelosuppression 75-97%
- Hyperbilirubinemia: 21%
- Thrombocytopenia: 97%/≥ grade 3: 67%
- Anemia: 62%/≥ grade 3: 18%
- Neutropenia: 75%/ ≥ 3: 34%
- Elevated serum creatinine: 41%
- Renal failure: 2-10%
- Hemorrhage: ≥ grade 3: 4%
- Fever: 26%
- Infection: 31%
- Sepsis: 6%
- Fatigue: < 60%/≥ grade 3: < 25%
- EKG T-wave changes: 40%/≥ grade 3: 3%
- Cardiac arrhythmias: 12%
- Peripheral edema: 29%
- Ischemic heart disease: 4%
- Orthostatic hypotension: 2-10%
- Electrolyte abnormalities
    - Less than 50% may experience
        - Decrease calcium, phosphate, potassium, sodium
    - Greater than 50%
        - Increase magnesium
- Weakness: < 60%/≥ grade 3: < 25%

Patient Care Considerations

- Monitor CBC, platelets and electrolytes
    - Ensure K and Mg are normal before administering
- Consider monitoring EKG in patients with:
    - History of cardiovascular disease and congenital long QT syndrome
    - Concurrent medications that can prolong QT interval
- Monitor for GI toxicity, infection and hemorrhage
- Monitor for toxicities related to increased panobinostat exposure when co-administering with strong CYP3A4 inhibitors, avoid if possible
- Avoid use with CYP2D6 substrates and strong CYP3A4 inducers
- Avoid star fruit, pomegranate (juice) and grapefruit (juice)
- Pregnancy test prior to treatment and intermittently during therapy
- Females should use contraceptives for 3 months after last dose
- Males should use contraceptives for 6 months after last dose
- Avoid breastfeeding during panobinostat treatment

mTOR Inhibitors

- Torisel (temosirolimus)
- Afinitor (everolimus)

Temsirolimus

- Indication
    - Advanced renal cell carcinoma
- Dosing, route, and administration
    - 25 mg IV over 30-60 minutes every week
        - Vial contents must be diluted with the enclosed diluent before diluting in 250 mL of 0.9% NaCl
- Premedication
    - Diphenhydramine 25-50 mg, thirty minutes before treatment
- Dosing adjustments
    - Hepatic
    - ANC < 1000
    - Platelets < 75k
        - Any grade 3 nonhematologic toxicity
- Contraindications
    - Moderate to severe hepatic impairment
- Box warning
    - None
- Dosage forms and cost
    - 25 mg/ml
    - $1910

Everolimus

- Indication
  - 10 mg PO once daily
  - Take with or without food
  - Do not chew, crush, or break
  - Tablets to make oral suspension are not interchangeable
- Premedication
  - None
- Dosing adjustments
  - Hepatic
  - ANC <500
  - Platelets < 50K
    - Grade 2 nonhematologic toxicity
  - Neutropenic fever
  - Pneumonitis
  - Stomatitis
  - Metabolic toxicity
- Dosage forms and costs
  - Tablets: 2.5, 5, 7.5, 10 mg Afinitor tablets
  - $673 per 10 mg tablet

Side Effects	Temsirolimus	Everolimus
Skin rash	47%	21-59%
Nail disease	14%	5-22%
Peripheral edema	35%	13-39%
Chest pain	16%	5%
Headache	15%	< 30%
Mucositis	41%	-
Vomiting	19%	15-29%
Diarrhea	27%	14-50%
Abdominal pain	21%	5-36%
Dysgeusia	20%	5-19%
Stomatitis	20%	44%/≥ grade three 4-9%
Decreased hemoglobulin	94%/≥ grade three < 15%	41-92%/≥ grade three < 15%
Decreased neutrophils	19%/≥ grade three 5%	14-46%/≥ grade three <9%
Thrombocytopenia	40%/≥ grade three < 1%	19-45%/> grade three 9%
UTI	15%	9-31%
Infections	20%/≥ grade three 3%	37-74%
Dyspnea	28%	20-24%
Pneumonia	8%	6-19%
Fever	24%	20-31%
Increased Alk Phos	68%/≥ grade three 3%	32-74%
Increased AST	38%/≥ grade three 2%	23-67%
Increased serum creatinine	57%/≥ grade three 3%	5-50%
Increased glucose	89%/≥ grade three 16%	-
Increased cholesterol	87%/≥ grade three 2%	66-85%

Hypertriglyceridemia	83%/≥ grade 44%	27-73%
Hypophosphatemia	49%/≥ grade three 18%	9-49%
Hyperglycemia	26%	13-75%
Hypocalcemia	-	37%
Hypokalemia	21%/≥ grade three 5%	23-27%
Hyperbilirubinemia	8%	3%
VTE	2%	< 1%
Hypertension	7%	4-13%
GI hemorrhage/perforation	1%	3%
Wound healing impairment	1%	< 1%

Temsirolimus Patient Care Considerations

- Monitor CBC, glucose, lipid profile, renal and hepatic function
- Monitor for GI toxicity, respiratory status, infection and hemorrhage
- Monitor for hypersensitivity reactions throughout entire infusion (Polysorbate 80)
- Avoid concomitant strong CYP3A4 inducers and/or inhibitors
    - Avoid grapefruit and grapefruit juice
- Use with caution in perioperative period due to risk of abnormal wound healing
- Handling precautions – do not handle bodily fluids without gloves
- Females should use contraceptives for three months after last temsirolimus dose
- Males with female partners should use contraceptives for three months after last temsirolimus dose
- Avoid breastfeeding during and for 3 weeks after last temsirolimus treatment

Everolimus Patient Care Considerations

- Monitor CBC, glucose, lipid profile, renal and hepatic function
- Monitor for GI toxicity, respiratory status, infection and hemorrhage
- Monitor for hypersensitivity reactions throughout entire infusion (Polysorbate 80)
- Avoid concomitant strong CYP3A4 inducers and/or inhibitors
    - Avoid grapefruit and grapefruit juice
- Use with caution in perioperative period due to risk of abnormal wound healing
- Handling precautions – do not handle medication or bodily fluids without gloves
- Can cause infertility
    - Females: menstrual irregularities, secondary amenorrhea, and increased LH and FSH / males: azoospermia and oligospermia
- Females should use contraceptives for two months after last everolimus dose
- Males with female partners should use contraceptives for 1 months after last dose
- Avoid breastfeeding during and for two weeks after last everolimus treatment

PI-3 Kinase Inhibitors

- Aliqopa (copanlisib)
- Zydelig (idelalisib)
- Piqrau (alpelisib)

Copanlisib

- Classification
  - Pan-PI3K Inhibitor
- Indication
  - Relapsed Follicular Lymphoma
- Dosing route and administration
  - 60 mg IV over 1 hour on D1, 8, 15 of a 28-day cycle
- Dosing adjustments
  - Mod-severe hepatic
  - ANC <500
  - Platelets <25K
  - Strong CYP3A inhibitors
  - Nonhematologic
- Dosage forms and cost
  - 60 mg vial
  - $5598 per vial

Idelalisib

- Classification
  - PI3K Isoform Specific
- Indication
  - Relapsed CLL, SLL, and Follicular B-cell NHL
- Dosing route and administration
  - 150 mg PO twice daily
  - Take with or without food
- Miscellaneous
  - Specialty Pharmacy
  - Medication Guide
  - Severe hypersensitivity
- Box Warnings
  - Diarrhea
  - Hepatic
  - Pneumonitis
  - Infection
  - GI perforation
- Dose adjustments
  - Hepatic: Treatment related
  - ANC < 500
  - Platelets < 25K
  - Diarrhea

- Dosage forms and cost
    - Tablets: 100, 150 mg
    - $225 each tablet

Alpelisib

- Classification
    - PI3K Isoform Specific
- Indication
    - Breast cancer: HR+/HER2-/PIK3CA mutated
- Dosing route and administration
    - 300 mg PO once daily with fulvestrant
    - Take with food
- Miscellaneous
    - Therapy pack tablets
- Dosing adjustments
    - Hepatic treatment-related
    - ANC < 500
    - Platelets < 25K
    - Nonhematologic
- Dosage forms and cost
    - Tablets: 50, 150, 200 mg
    - Therapy Pack: 200, 250, 300
    - $700 each therapy pack

Side Effects	Copanlisib	Idelalisib	Alpelisib
Fatigue	36%	30%	42%
Hypertension	35%	-	-
Peripheral edema	-	10%	15%
Alopecia	-	10%	15%
Skin rash	15%	21%	52%
Diarrhea	36%	47%/≥ grade 3: 3%	58%/≥ grade 3: 3%
Nausea/vomiting	21%/13%	29%/15%	45%/27%
Stomatitis	14%	-	30%
Hyperglycemia	54-95%/≥ grade 3: 3-5%	59%	65%
Hypertriglyceridemia	58%	62%	-
Anaphylaxis	-	< 1%	0.7%
Severe dermatologic reaction	< 1%	< 1%	< 1%
Lower respiratory tract infection	21%	12%	-
Pneumonia	8%	15-25%	-
Pneumonitis	5-9%	4%	2%
Serious infection	19%	21%	< 1%
Neutropenia	32%/≥ grade 3: 10-24%	60%/≥ grade 3: 31%	42%/≥ grade 3: 4%

Decreased hemoglobulin	78%/≥ grade 3: 4%	28%/≥ grade 3: 6%	-
Thrombocytopenia	22%/≥ grade 3: 8%	26%/≥ grade 3: 6%	14%/≥ grade 3: 1%
Lymphocytopenia	78%/≥ grade three 29%	-	52%/≥grade 3: 8%
Abdominal pain	-	26%	17%
Hepatotoxicity	-	14%	-
Increased ALT/AST	-	35%/25%	44%/-
Increased serum creatinine	-	-	67%

Copanlisib: Patient Care Considerations

- Monitor CBC weekly
- Monitor BP and blood glucose before and after each copanlisib dose
- Monitor for infections
- Monitory for signs and symptoms of dermatologic toxicity (TEN) and respiratory
- Do not take or start any new medications or supplements
    - Drug-drug interactions: CYP 3A inhibitors (including grapefruit) and inducers
- Monitoring pregnancy status (prior to, during, and for one month after last dose)
- Females should use contraceptives during and for one month after last dose
- Males with female partners should use contraceptives during and for 1 month after last copanlisib dose
- Avoid breastfeeding during and for 1 month after last copanlisib dose

Idelalisib: Patient Care Considerations

- Patient should be provided a medication guide and counseled about idelalisib
- Monitor CBC every two weeks for six months
- Monitor liver function every two weeks for three months, then monthly for 3 months, at least every 3 monthly thereafter
- Monitor for infections, sepsis/pneumonia, and opportunistic infections, pneumocystis carinii pneumonia (PCP), viral
- Monitory for s/s diarrhea/colitis, dermatologic toxicity, hypersensitivity (anaphylaxis), GI, and respiratory pneumonitis
- Do not take or start any new medications or supplements
    - Drug-drug interactions: CYP 3A inhibitors and inducers
- If miss a dose and it is > 6 hours from normal dosing time, skip the dose and wait for the next scheduled dose
- Monitoring pregnancy status (prior to, during, and for 1 month after last dose)
- Females should use contraceptives during and for 1 month after last idelalisib dose
- Males with female partners should use contraceptives during and for 3 months after last idelalisib dose
- Avoid breastfeeding during and for 1 month after last idelalisib dose

Alpelisib: Patient Care Considerations

- Monitor fasting glucose prior to, once weekly for 2 weeks, then monthly as clinically indicated
    - HbA1c prior to and every 3 months during treatment as indicated
- Monitor for s/s of diarrhea, skin reactions, hypersensitivity, hyperglycemia, respiratory symptoms
- Do not take or start any new medications or supplements
    - Drug-drug interactions: CYP 3A inducers, BCRP inhibitors, or CYP 2C9 substrates
- If miss a dose and it is > 9 hours from normal dosing time, skip the dose and wait for the next scheduled dose
- Handling precautions: Use gloves to handle alpelisib
- Monitoring pregnancy status: Prior to treatment, during treatment, and for 1 week after discontinuation
    - Embryofetal toxicity
- Females should use contraceptives during and for 1 week after last alpelisib dose
- Males with female partners should use contraceptives during and for 1 week after last dose
- Avoid breastfeeding during and for 1 week after last alpelisib dose

CDK4/6 Inhibitors

- Ibrance (palbociclib)
- Kisqali (ribociclib)
- Verzenio (abemaciclib)

Palbociclib

- Indication: Breast Cancer HR+/HER2-
    - 1st line - postmenopausal
    - 2nd line
- Dosing, route and administration
    - 125 mg PO once daily for 21 days of a 28-day cycle
    - Same time each day
    - Do not chew, crush, or break
- Miscellaneous
    - Specialty pharmacy
    - Tablets with or without food
    - Capsules with food
- Dosing adjustments
    - Severe hepatic
        - Grade 3 hematologic toxicity
    - Strong CYP3A inhibitors
- Dosage forms and cost
    - Capsules: 75, 100, 125mg
    - Tablets: 75, 100, 125 mg
    - $711 each tablet or capsule

Ribociclib

- Indication
  - Breast Cancer (HR+/HER2-)
  - 1st line - postmenopausal
  - 2nd line
- Dosing, route and administration
  - 600 mg PO once daily for 21 days of a 28-day cycle
  - Take in AM, preferred
  - Do not chew, crush, or break
- Miscellaneous
  - Tablet therapy packs for 200, 400, 600 mg dose
  - Take with or without food
- Dosing adjustments
  - Mod to severe hepatic
  - Renal
  - > grade 2 hepatobiliary
  - > grade 2 pulmonary
  - > grade 3 neutropenia
  - QTc > 480
  - Strong CYP3A inhibitors
  - > grade 3 nonhematologic
- Dosage forms and cost
  - Therapy pack 200, 400mg
    - $302 each 200 mg tablet
  - Therapy pack 600 mg
    - $252 each 200 mg tablet

Abemaciclib

- Indication
  - Breast Cancer HR+/HER2-
  - 1st line postmenopausal
  - 2nd line
- Dosing, route, and administration
  - 150 mg PO twice daily
  - 200 mg PO twice daily
  - Same time each day
  - Do not chew, crush, or break
- Miscellaneous
  - Specialty Pharmacy
  - Tablets-with or without food

- Dosing adjustments
  - Severe hepatic
  - > grade 3 hepatotoxicity
  - > grade 3 hematologic toxicity
  - Strong CYP3A inhibitors
  - > grade 2 diarrhea
  - > grade 2 pulmonary
  - > grade 3 nonhematologic
- Dosage forms and cost
  - Tablet: 50, 100, 150, 200mg
  - $265 each tablet

Potential Drug-Drug Interactions

	Palbociclib	Ribociclib	Abemaciclib
Drug-drug interactions	• CYP 3A inhibitors • CYP 3A inducers • CYP 3A substrates • Grapefruit juice	• CYP 3A inhibitors • CYP 3A inducers • CYP 3A substrates • QTc prolonging agents • Grapefruit juice • Pomegranate	• CYP 3A inhibitors • CYP 3A inducers • Grapefruit juice

Side Effects	Palbociclib	Ribociclib	Abemaciclib
Neutropenia	80%/≥ grade 3: 66.5%	74%/≥ grade 3: 59%	41%/≥ grade 3:21%
Anemia	24%/≥ grade 3: 5%	19%/≥ grade 3: 1%	28%/≥ grade 3: 6%
Thrombocytopenia	15%	10%	6%
Infections	60%	50%	39%
Diarrhea	26%	35%	81%
Nausea	35%	52%	39%
Vomiting	16%	29%	28%
Rash	18%	17%	14%
Alopecia	33%	33%	27%
Fatigue	37%	37%	40%
Increased ALT/AST	10%	15%	15%
QTc prolongation	-	7.5%/≥ grade 3: 3%	-

Patient Care Considerations

- Monitor CBC (with differential) and hepatic function
    - Baseline, every two weeks for the first two cycles, then prior to each cycle thereafter
- Monitor for signs and symptoms of diarrhea/dehydration, VTE, infection, and interstitial lung disease/pneumonitis
- Do not start or take new medications without notifying health provider
    - Avoid CYP 3A4 inhibitors and inducers
- For ribociclib, monitor electrolytes and EKG/cardiac function
    - Avoid concomitant administration with other QTc prolonging agents
- Pregnancy test prior to treatment
- Females should use contraceptives during and for three weeks
    - Three months for palbociclib after last dose
- Avoid breastfeeding during and for $\geq$ three weeks after last dose

PARP Inhibitors

- Lynparza (olaparib)
- Rubraca (rucaparib)
- Zejula (niraparib)
- Talzenna (talazoparib)

Olaparib

- Indication
    - Met breast HER2- /BRCA mutated
    - Advanced ovarian: BRCA mutated or homologous recombination deficient positive
        - Maintenance
    - Recurrent ovarian: Maintenance
    - Metastatic pancreatic, BRCA mutated: maintenance
    - Metastatic prostate: Castration resistant /homologous recombination repair gene mutated
- Dosing route and administration
    - Tablets: 300 mg PO twice daily
    - Take with or w/o food
    - Do not chew, crush, dissolve, or divide tablets
- Miscellaneous
    - Specialty Pharmacy
    - Medication Guide
    - Nausea/vomiting more common if taken on empty stomach

- Dosing adjustments
    - CYP3A inhibitors and inducers
    - Renal
    - Nonhematologic
- Dosage forms and cost
    - Tablets: 100, 150 mg
    - $142 per tablet

Rucaparib

- Indication
    - Advanced ovarian cancer: BRCA mutated
        - > Two lines treatment
    - Recurrent ovarian cancer
        - Maintenance
    - Metastatic prostate cancer: Castrate-resistant/BCRA mutated
- Dosing, route and administration
    - 600 mg PO twice daily
    - Take with or w/o food
- Miscellaneous
    - Moderately emetogenic
        - May need antiemetic
- Dosing adjustment
    - Prolonged hematologic
        - > 4 weeks
- Dosage forms and costs
    - Tablets: 200, 250, 300 mg
    - $167 per tablet

Niraparib

- Indication
    - Advanced ovarian, fallopian tube, or primary peritoneal cancer
        - Maintenance or >3 lines of chemotherapy
- Dosing route and administration
    - Maintenance: 300 mg PO once daily
        - >77 kg or platelets > 150K
    - 200 mg PO once daily
        - < 77 kg or platelets < 150K
    - Metastatic: 300 mg PO once daily
- Miscellaneous
    - Moderately emetogenic
        - May need antiemetic
    - Maintenance dose depends on weight
        - < or > 77 kg and platelets < or >150K

- Dosing adjustments
    - ANC < 1000
    - Platelets < 100K
    - Any > grade 3 nonhematologic
- Dosage forms and adjustments
    - Capsule: 100 mg
    - $290 each capsule

Talazoparib

- Indication
    - Locally advanced or metastatic breast cancer HER2-/BRCA mutated
- Dosing, route and administration
    - 1 mg PO once daily
    - Take with or w/o food
    - Swallow capsule whole
- Dosing adjustments
    - P-gp inhibitors
    - Renal insufficiency
    - Hgb <8
    - ANC < 1000
    - Platelets < 50K
        - Any > grade 3 nonhematologic toxicity
- Dosage forms and costs
    - Capsule: 0.25, 1 mg
    - $612 each 1mg
    - $204 each 0.25mg

Side Effects	Olaparib	Rucaparib	Niraparib	Talazoparib
Fatigue	< 67%	< 73%	< 57%	62%
Headache	15-26%	18%	26%	33%
Dizziness	7-20%	19%	18%	17%
Alopecia	-	-	-	25%
Skin rash	5-6%	43%	21%	-
Nausea/vomiting	58-77%/30-43%	76%/32%	74%/34%	49%/25%
Diarrhea	21-37%	32%	20%	22%
Constipation	16-28%	37%	40%	-
Abdominal pain	45%	< 46%	33%	19%
Increased glucose	-	-	-	54%
Decreased calcium	-	-	-	54%
Increased cholesterol	-	84%	-	-
Anemia	23-44% ≥ grade 3: 7-21%	39%/≥ grade 3: 21%	50%/≥ grade 3: 25%	53%/≥ grade 3: 39%
Neutropenia	5-27%/≥ grade 3: 6-9%	20%/≥ grade 3: 8%	30%/≥ grade 3: 20%	35%/≥ grade 3: 21%

Thrombocytopenia	4-14%/≥ grade 3: 1%	29%/≥ grade 3: 5%	61%/≥ grade 3: 29%	27%/≥ grade 3: 15%
Increased AST/ALT	-	< 61%/< 28%	< 36%/< 28%	37%/33%
Increased ALK phos	-	37%	< 10%	36%
Increased serum creatinine	3-45%	98%	< 10%	-
Secondary AML/MDS	< 1.5%	0.5%	0.9%	0.3%
Back pain	14%	-	18%	-
Insomnia	-	15%	27%	-
Hypertension	-	-	20%/≥ grade 3: 9%	-
Dysgeusia	9-21%	40%	10%	10%

Olaparib: Patient Care Considerations

- Monitor CBC (baseline and monthly) and renal function
- Monitor s/s of AML/MDS and pneumonitis
- If a dose is missed or vomited, do not give an additional dose
    - Administer dose at the next scheduled time
- Do not start or take new medications without notifying health provider
    - Avoid strong CYP3A inhibitors and inducers
- Handling precautions
    - Do not handle medication without gloves
- Monitoring pregnancy status prior to treatment, during treatment, and for 6 months after discontinuation
    - Embryo-fetal death
- Females should use contraceptives during and for 6 months after last olaparib dose
- Males with female partners should use contraceptives during and for 3 months after last olaparib dose
- Avoid breastfeeding during and for 1 month after last olaparib treatment

Rucaparib: Patient Care Considerations

- Monitor CBC
    - Baseline and monthly
- Monitor signs and symptoms of AML/MDS
- If a dose is missed or vomited, do not give an additional dose
    - Administer dose at the next scheduled time.
- Do not start or take new medications without notifying health provider
    - Substrate for CYP1A2, CYP3A, CYP2C9, CYP2C19
- Handling precautions
    - Do not handle medication without gloves

- Monitoring pregnancy status prior to treatment, during treatment, and for 6 months after discontinuation
    - Embryo-fetal death
- Females should use contraceptives during and for 6 months after last rucaparib dose
- Males with female partners should use contraceptives during and for 3 months after last rucaparib dose
- Avoid breastfeeding during and for two weeks after last rucaparib treatment

Niraparib: Patient Care Considerations

- Monitor CBC weekly for first month, then monthly for next eleven months
- Monitor BP and heart rate weekly for the first two months, then monthly for first year
- Monitor signs and symptoms of AML/MDS
    - If a dose is missed or vomited, do not give an additional dose: Administer dose at the next scheduled time
    - Handling precautions: Do not handle medication without gloves
- Monitoring pregnancy status prior to treatment, during treatment, and for 6 months after discontinuation
    - Embryo-fetal death
- Females should use contraceptives during and for six months after last niraparib dose
- Avoid breastfeeding during and for one month after last niraparib dose

Talazoparib: Patient Care Considerations

- Monitor CBC and renal function
- Monitor signs and symptoms of AML/MDS
    - If a dose is missed or vomited, do not give an additional dose: Administer dose at the next scheduled time
- Do not start or take new medications without notifying health provider
- Avoid P-gp inhibitors: Increases talazoparib exposure
    - Handling precautions: Do not handle medication without gloves
- Monitoring pregnancy status prior to treatment, during treatment, and for 7 months after discontinuation
    - Embryo-fetal death
- Females should use contraceptives during and for seven months after last dose
- Males with female partners should use contraceptives during and for four months after last dose
- Avoid breastfeeding during and for and month after last talazoparib treatment

Hedgehog Pathway Inhibitors

- Erivedge (vismodegib)
- Odomzo (sonidegib)

Vismodegib

- Indication
  - Metastatic or locally advanced basal cell carcinoma (BCC) that has recurred following surgery or radiation therapy, or those not candidates for surgery or radiation therapy
- Dosing, route and administration
  - 150 mg PO once daily
  - Take with or without food
  - Do not chew or crush
  - Antiemetic required
- Miscellaneous
  - Erivedge Access Solutions program
  - Specialty pharmacy
  - Must dispense medication guide
- Dosing adjustments
  - None
    - Intolerable toxicity withhold up to eight weeks for resolution
- Box warning
  - Embryofetal toxicity
- Dosage form and cost
  - Capsule: 150 mg
  - $490 each capsule

Sonidegib

- Indication
  - Metastatic or locally advanced basal cell carcinoma (BCC) that has recurred following surgery or radiation therapy, or those not candidates for surgery or radiation therapy
- Dosing, route and administration
  - 200 mg PO once daily
  - Administer on an empty stomach > one hour before or two hours after a meal
  - High fat meal increases concentration 7-8-fold
- Miscellaneous
  - Verify pregnancy status prior to treatment
  - Obtain serum creatine kinase and renal function prior treatment
  - Must dispense medication guide
- Dosing adjustment
  - Creatine kinase elevation > 2.5 x ULN
- Box warning
  - Embryofetal toxicity

- Dosage form and cost
    - Capsule: 200 mg
    - $474 each capsule

Side Effects	Vismodegib	Sonidegib
Headache	-	15%
Decreased appetite	-	23%
Abdominal pain	-	18%
Weight loss	45%	30%
Dysgeusia	55%	46%
Increased LFTs	-	19%
Increased amylase	-	16%
Increased serum lipase	-	43%
Pruritis	-	10%
Hyperglycemia	-	51%
Amenorrhea	30%	< 1%
Azotemia	grade 3: 2%	-
Fatigue	40%	41%
Alopecia	64%	53%
Nausea	30%	39%
Diarrhea	29%	32%
Anemia	-	32%
Lymphocytopenia	-	28%/≥ grade 3: 3%
Increased creatinine phosphokinase	38%	61%/≥ grade 3: 8%
Muscle spasm	72%	54%/grade 3: 8%
Musculoskeletal pain	-	32%/grade 3: 1%
Increased serum creatinine	-	32%/grade 3: 1%
Myalgia	-	19%
Arthralgia	16%	-

Vismodegib: Patient care considerations

- Monitor CBC and comprehensive metabolic panel baseline and every 4 weeks
- Monitor liver function and perform skin examination routinely during therapy
    - Cutaneous squamous cell cancer (cuSCC) cases have been reported
- Monitoring pregnancy status one week prior to treatment, monthly during treatment, and for 24 months after discontinuation
    - May cause severe birth defects and embryo-fetal death
- Females should use contraceptives during and for 24 months after last dose
- Males with female partners should use contraceptives during and for three months after last vismodegib dose
- Avoid breastfeeding during and for 24 months after last vismodegib treatment
- Blood donations
    - Wait ≥ seven months
- Sperm donations
    - Wait ≥ three months

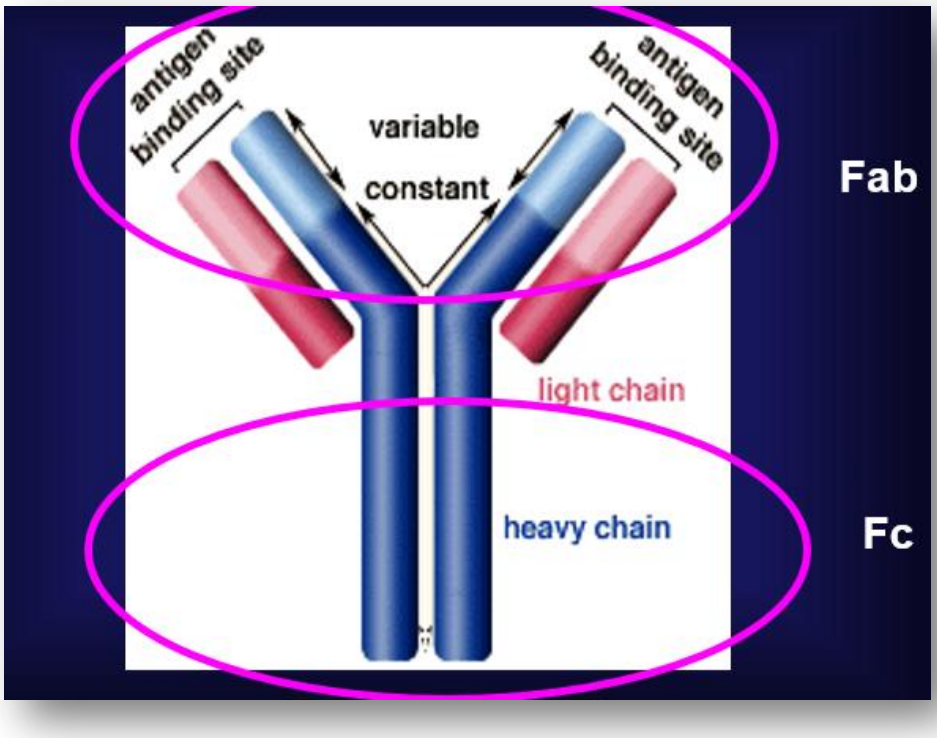
Sonidegib: Patient Care Considerations

- Monitoring serum creatine kinase (CK)
- Monitor serum creatinine baseline and periodically during treatment
- Monitor liver function
- Monitor for signs/symptoms of musculoskeletal toxicity
- Monitoring pregnancy status one week prior to treatment, monthly during treatment, and for 24 months after discontinuation
    - May cause severe birth defects and embryo-fetal death
- Females should use contraceptives during and for 20 months after last sonidegib dose
- Males with female partners should use contraceptives, even after vasectomy, during and for eight months after last sonidegib dose
- Avoid breastfeeding during and for 20 months after last sonidegib treatment
- Blood donations
    - Wait $\geq$ 20 months
- Sperm donations
    - wait $\geq$ 8 months
- Amenorrhea
    - May last at least 18 months

The Role of Monoclonal Antibodies in Hematology/Oncology

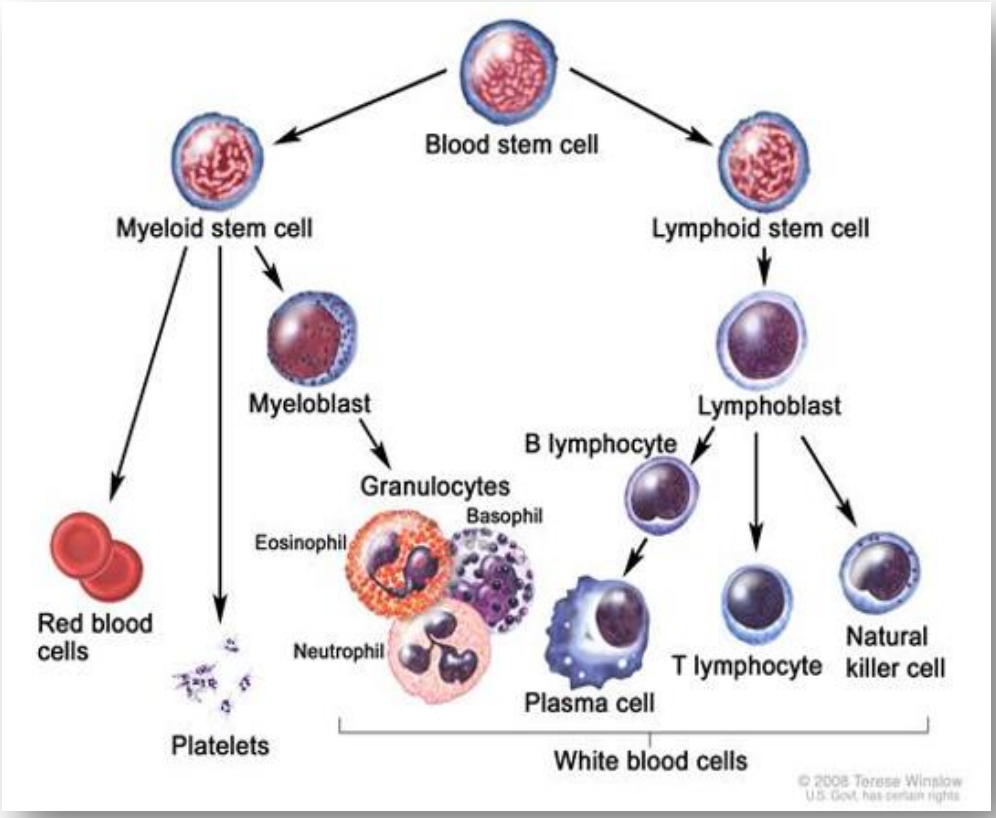
Antibodies

- Proteins produced mainly by plasma cells and used by the immune system to neutralize pathogens
- Monoclonal antibodies: Made by identical immune cells that are all clones of a unique parent cell and thus bind to a common epitope
- Polyclonal antibodies: Bind to multiple epitopes and are usually made by several different plasma cell (antibody secreting immune cell) lineages



Function of Antibodies

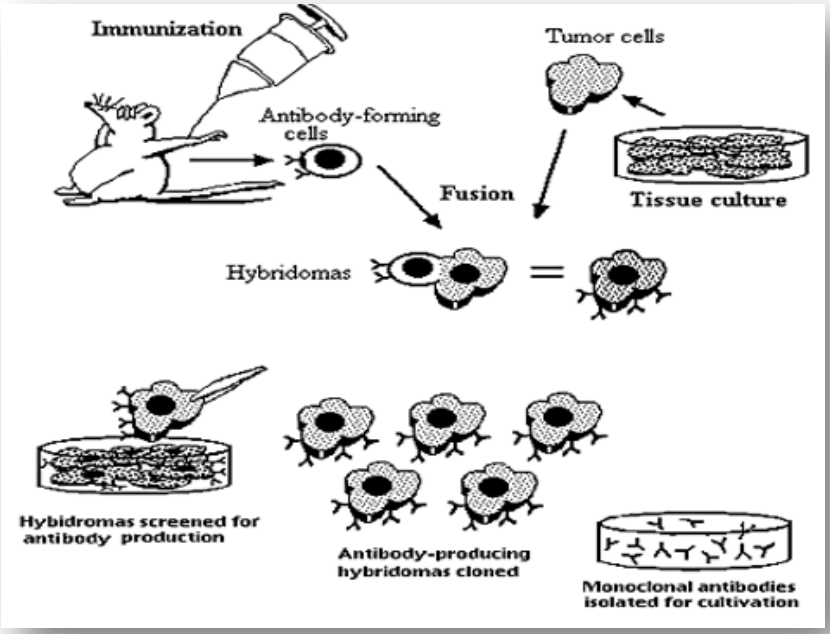
- Protect host organism
- Bind and neutralize toxins
- Activate immune system
    - Lyses target cells
    - Initiation of cellular response on natural killer cells, monocytes, and macrophages
- Different isotypes and subclasses differ in ability to activate this response
    - IgA, IgD, IgE, IgG, IgM



Improving Selectivity of Cancer Treatment

- Direct activity against therapeutic targets
- Limit adverse drug effects through specific targets
- Two new agents
    - Low molecular weight compounds, tyrosine kinase inhibitors (TKI)
    - Monoclonal antibodies (mAb)

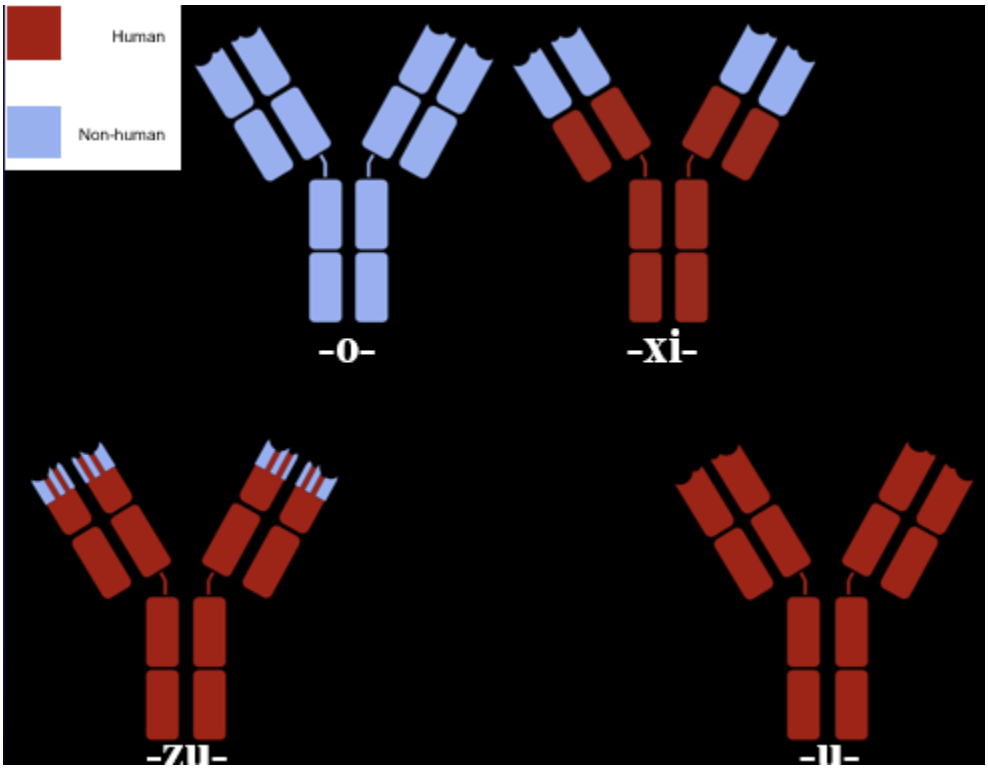
Development of Monoclonal Antibodies



Types of Monoclonal Antibodies

- Murine antibodies
  - Recognized by host immune system
  - Antibodies developed
  - Allergic reactions
- Chimeric: Human/mouse
  - Constant domains replaced by human
- Humanized
  - Antibodies that are 95% human
- Fully human
  - No mouse portions

Types of Monoclonal Antibodies



What's in a Name

Abbreviation	Antibody Source	Example
mo	mouse	moxetumomab pasudotox
xi	chimeric	rituximab
zu	humanized	trastuzumab
mu	human	panitumumab

Which of the following is a chimeric monoclonal antibody?

A. Pembrolizumab
B. Daratumumab
C. Ramucirumab
D. Cetuximab

CD20-Directed Monoclonal Antibodies

Rituxan (rituximab)

- Approved in 1997
- Chimeric IgG1 monoclonal antibody
- Directed against CD20 antigen
    - Expressed on the surface of most B-cells
        - Regulates cell cycle initiation
        - Good target for many B-cell malignancies
    - Causes cytotoxicity

Federal Drug Administration (FDA) Indications

- Non-Hodgkin's lymphoma (NHL), diffuse, large B-cell lymphoma (DBCL), in combination for first-line treatment
- NHL, follicular, B-cell, in combination with cyclophosphamide, vincristine, and prednisone (CVP) for first-line treatment AND maintenance
- NHL, low-grade, B-cell, stable/responsive to prior CVP
- NHL, relapsed or refractory, low-grade or follicular, B-cell
- Chronic lymphocyte leukemia (CLL) in combination with Fludara and Cytoxan (FC)

Warnings and Precautions

- Hypersensitivity/infusion reactions
    - Fevers, chills, rigors
    - Hypotension, bronchospasm, angioedema
- Reactions: 30 min to 2 hours from start of infusion
- Decreases with subsequent infusions
- Vitals
    - Every 15 minutes for 1 hour, then every 30 minutes for rest of infusion

Management of Rituxan Reactions

- Pre-medications
    - Diphenhydramine 50 mg IVP
    - Acetaminophen 650 mg PO
    - +/- corticosteroid
- Meperidine, epinephrine, corticosteroids, bronchodilators, IV saline PRN
- Interrupt infusion for severe reactions
    - Resume at 50% rate
- Usually mixed as 1 mg/mL
    - Final concentration 1-4 mg/mL

Warnings and Precautions

- Tumor lysis syndrome (TLS)
  - Acute renal failure
  - Cell lysis from rituximab
  - Can be fatal
  - Monitor labs before and after
- Hepatitis B reactivation
- Progressive multifocal leukoencephalopathy (PML): Rare, progressive, demyelinating disease of the CNS from JC virus

Dosing and Administration

- Dose: 375 mg/m^2 IV infusion (per protocol)
  - Do not administer intravenous push (IVP) or bolus
- Administration
  - First infusion: 50 mg/hour, can escalate in 50 mg/hr increments every 30 minutes
  - Max: 400 mg/hr
  - Subsequent infusions: 100 mg/hr and can increase 100 mg/hr every 30 minutes
- Infusion related events
  - Slow or discontinue IV infusion
  - Monitor vital signs

Rapid Infusion Administration

- First dose standard
- If initial infusion tolerated without $\geq$ grade 3 infusion reaction, proceed to rapid infusion for doses up to 1000 mg
- For Rapid Infusion: 90 minutes
  - Mix in total volume of 250 mL and initiate infusion at 100 mL/hr x 30 minutes
  - If no reaction, infuse remaining rituximab at a rate of 200 mL/hr

Rituxan Hycela

- Rituximab and hyaluronidase human injection for subcutaneous use
- Use in FL, DLBCL, CLL
- Initiate treatment only after patients have received at least one full dose of a rituximab by IV infusion

Administer

- FL/DLBCL: Administer 1,400 mg/23,400 Units SQ according to recommended schedule
- CLL: Administer 1,600 mg/26,800 Units SQ according to recommended schedule
- Premedicate with acetaminophen and antihistamine
- Administer specified volume into subcutaneous tissue of abdomen
- 11.7 mL from 1,400 mg/23,400 Units vial over 5 minutes
- 13.4 mL from 1,600 mg/26,800 Units vial over 7 minutes
- Observe 15 minutes following administration

Arzerra (ofatumumab)

- Approved in 2009
- Human IgG1 monoclonal antibody
- CD20-directed cytolytic monoclonal antibody

FDA Indications

- Treatment of adults with CLL refractory to fludarabine and alemtuzumab
- Combination with chlorambucil for patients with previously untreated CLL
- Treatment/maintenance of patients with recurrent or progressive CLL who are in a complete response (CR) or Partial response (PR) after $\geq$ 2 or more lines of prior therapy

Mechanism of Action

- Binds CD20, which is expressed on normal B lymphocytes and on B-cell CLL
- Results in B-cell lysis
- Complement-dependent and antibody-dependent, cell-mediated cytotoxicity are suggested mechanisms of cell lysis

Warnings and Precautions

- Hypersensitivity/infusion reactions
    - Up to 44% with first infusion
    - Decreased with subsequent infusion
- Cytopenias
- PML
- Hepatitis B reactivation
- Intestinal obstruction
- Most common $\geq$ 10%
    - Neutropenia, pneumonia, fever, cough, diarrhea, anemia, fatigue, SOB, rash, nausea, respiratory infections

Management of Reactions

- Premedicate with acetaminophen 1000 mg IV/PO, antihistamine IV/PO, and corticosteroid IV 30 minutes to 2 hours prior to each dose of ofatumumab
- Do not reduce corticosteroid dose for doses 1, 2, and 9
- May reduce corticosteroid for doses 3 through 8, and 10 through 12
    - Doses 3 through 8, if $\geq$ grade 3 infusion reaction did not occur with the preceding dose, gradually reduce corticosteroid dose
    - Doses 10 through 12, if $\geq$ grade 3 infusion reaction did not occur with dose 9, administer prednisolone 50 to 100 mg or equivalent

Dosing

- 300 mg IV as initial dose
    - Followed 1 week later by 2000 mg IV weekly for 7 doses: dose 2-8
    - Followed 4 weeks later by 2000 mg IV every 4 weeks for 4 doses: dose 9-12
- Prepare all doses in 1000 mL 0.9% sodium chloride
- Do not administer IV push or bolus
- Premedicate before IV infusion
- Administer with in-line filter supplied with product

Administration: Increase the rate of infusion every 30 minutes as directed

- Dose 1: Initiate at 3.6 mg/hr: 12 mL/hr
- Dose 2: Initiate at 24 mg/hr: 12 mL/hr
- Dose 3-12: Initiate at 50 mg/hr: 25 mL/hr
- Increase rate of infusion every 30 minutes as directed

Dose/Rate

Interval after start of infusion	300 mg (03.mg/ml) ml/hr	2000 mg (2mg/ml) ml/hr	2000 mg (2 mg/hr) ml/hr
0-30	12	12	25
31-60	25	25	50
61-90	50	50	100
91-120	100	100	200
> 120	200	200	400

Gazyva (obinutuzumab)

- Approved November 2013
- A glycoengineered type II anti-CD20 monoclonal antibody

Mechanism of Action

- Monoclonal antibody that targets the CD20 antigen expressed on the surface of pre-B- and mature B-lymphocytes
- Upon binding to CD20, obinutuzumab mediates B-cell lysis
    - Activates complement-dependent cytotoxicity, antibody-dependent cellular cytotoxicity, and antibody-dependent cellular phagocytosis, resulting in cell death
- Type I anti-CD20 monoclonal antibodies redistribute CD20 into membrane lipid rafts and potently activate complement, whereas type II anti-CD20 monoclonal antibodies do not activate complement
- More potently evoke direct program cell death
    - Programmed cell death may contribute toward the superior efficacy of type II anti-CD20 mAbs

Indications and Usage

- Previously untreated CLL: In combination with chlorambucil
- FL: In combination with bendamustine followed by obinutuzumab maintenance for disease after treatment with a rituximab regimen
- Untreated FL: In combination with chemotherapy followed by maintenance
- Treatment naïve CLL: In combination with ibrutinib or venetoclax

Dosage and Administration

- Premedicate with glucocorticoid, acetaminophen and antihistamine
- Dilute into a 0.9% sodium chloride PVC or non-PVC polyolefin infusion bag
    - Do not use other diluents such as dextrose
    - Do not administer as an IV push or bolus
    - Product can be administered at a final concentration of 0.4 mg/mL to 4 mg/mL
- Recommended dose for 6 cycles (28-day cycles)
    - 100 mg on day 1 Cycle 1
    - 900 mg on day 2 Cycle 1
    - 1000 mg on day 8 and 15 of Cycle 1
    - 1000 mg on day 1 of Cycles 2-6

Dosage and Administration Gazyva

Day of treatment cycle	Patients requiring pre-medication	Pre-medication	Administration
Cycle 1: Day 1 and 2	All patients	• Intravenous glucocorticoid: 20 mg dexamethasone or 80 mg methylprednisolone • 650–1000 mg acetaminophen • Antihistamine ○ (diphenhydramine 50 mg)	• Completed at least 1 hour prior to Gazyva infusion. • At least 30 minutes before Gazyva infusion.
Cycle 1: Day 8, and 15	All Patients	650–1000 mg acetaminophen	At least 30 minutes before Gazyva infusion.
Cycles 2-6: Day 1	Patients with a grade 3 IRR with the previous infusion or with lymphocyte count > 25 x 10^9/L prior to next treatment	Intravenous glucocorticoid: 20 mg dexamethasone or 80 mg methylprednisolone	Completed at least 1 hour prior to Gazyva infusion.

Dosage and Administration Gazyva

Day of 28-day treatment cycle		Dose of Gazyva	Rate of infusion (in the absence of infusion reactions/hypersensitivity during previous infusions)
Cycle 1	Day 1	100 mg	Administer at 25 mg/hr over 4 hours. Do not increase the infusion rate.
	Day 2	900 mg	Administer at 50 mg/hr. The rate of the infusion can be escalated in increments of 50 mg/hr every 30 minutes to maximum rate of 400 mg/hr
Cycle 1	Day 8, 15, and day 1 of remaining cycles	1000 mg	Infusions can be started at rate of 100 mg/hr and increased by 100 mg/hr increments every 30 minutes to a maximum of 400 mg/hr

Warnings and Precautions

- Tumor lysis syndrome
- Bone Marrow suppression
- Hepatitis B reactivation
- PML
- Immunization
    - Do not administer live virus vaccines prior to or during treatment
- Infusion reactions
    - Premedicate with glucocorticoid, acetaminophen and antihistamine prior to infusion
    - Hypotension may occur with infusions
        - Consider withholding antihypertensives 12 hours prior and for first hour after infusion

All the following target CD20 except:

A. Rituximab
B. Ofatumumab
C. Obinutuzumab
D. Trastuzumab

HER2-Directed Monoclonal Antibodies

Herceptin (trastuzumab)

- Humanized IgG1 monoclonal antibody

Indications: Must express human epidermal growth factor receptor 2 (HER-2/*neu*) protein

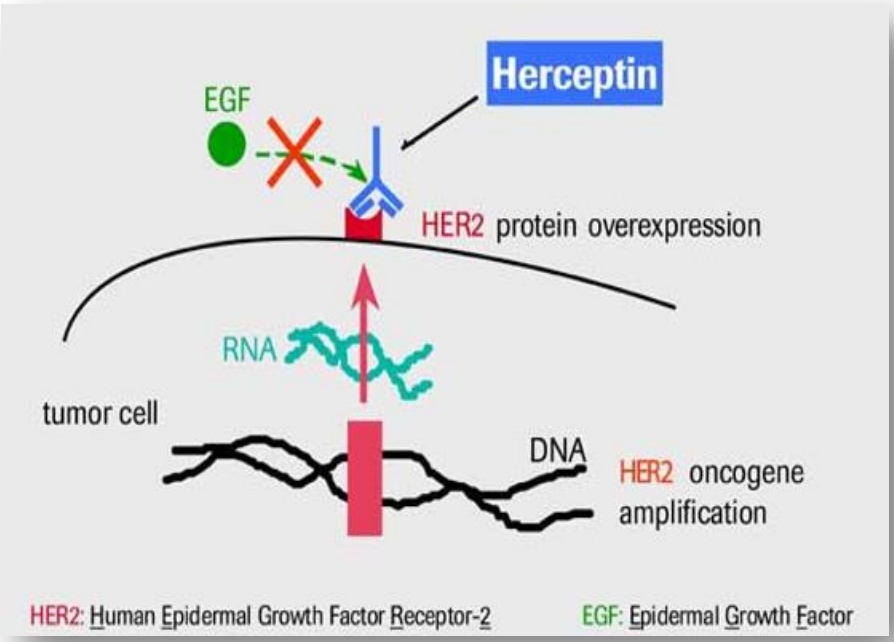
- Single agent, adjuvant treatment, node-negative (estrogen or progesterone receptor-negative or with one high-risk feature) or node-positive, following multi-modality anthracycline-based therapy
- Adjuvant therapy: Combination
    - As part of a treatment regimen containing doxorubicin, cyclophosphamide, and either paclitaxel or docetaxel
    - With docetaxel and carboplatin
- Single agent for metastatic breast cancer and has received one or more chemotherapy regimens
- Used with paclitaxel in metastatic breast cancer and have not received chemotherapy
- Malignant neoplasm of cardio-esophageal junction of stomach, Metastatic, HER2 overexpression, initial treatment, in combination with cisplatin and capecitabine or 5-fluorouracil

HER-2/*neu*

- Member of tyrosine kinase family
    - Includes EGFR
- Worse survival if expressed
    - 20*30% of breast cancers
    - Hormone receptor negativity or reduced sensitivity
    - Reduced sensitivity to chemotherapy
        - Anthracyclines may be exception
- Immunohistochemical technique: 3+
- Fluorescence *in situ* hybridization (FISH)
    - FISH testing for all IHC 2+
- Overexpressed in ovarian, gastric, colorectal, endometrial, lung, bladder, prostate, salivary gland tumors

Mechanism of Action Trastuzumab

- Binds to extracellular domain of the HER-2/*neu*
- Mediates antibody dependent cellular cytotoxicity



Warnings and Precautions

- Congestive heart failure: 3-7%
  - Cardiac failure, death, thrombus, stroke
- Left ventricle ejection fraction (LVEF) must be monitored
  - Prior to and during treatment
- Discontinue treatment if clinically significant decrease in LVEF
- Caution with other cardio-toxic chemotherapy
  - Anthracyclines and cyclophosphamide

Risk Factors

- Age
- Cardiac disease
- Chest radiation
- Previous anthracycline exposure

Dose: DO NOT MIX IN D5W

- Initial
  - 4 mg/kg or 8 mg/kg IV over 90 minutes
- Maintenance: Total 52 weeks of therapy
  - 2 mg/kg IV over 90 minutes weekly
    - Can be over 30 minutes if tolerate prior infusions
  - 6 mg/kg IV over 90 minutes every 3 weeks

If Infusion Reaction Occur

- Acetaminophen and diphenhydramine
- Meperidine PRN for rigors
- May have to reduce rate of infusion

Herceptin Hylecta (trastuzumab - and hyaluronidase-oysk)

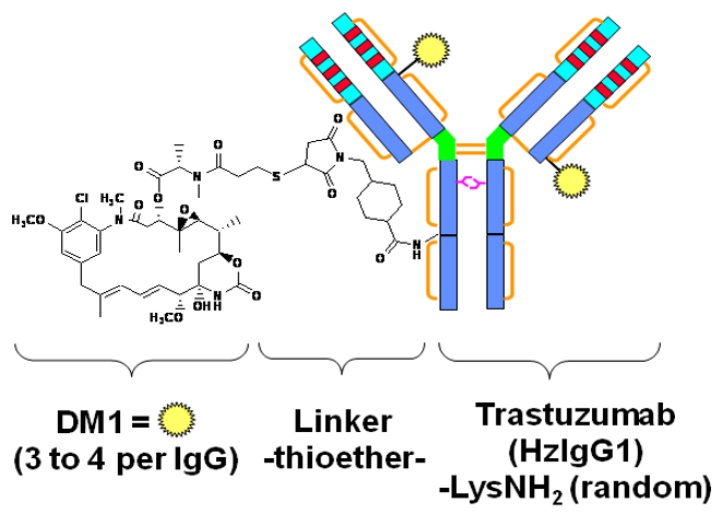
- Herceptin Hylecta is for subcutaneous use only
- Different dosage and administration instructions than intravenous trastuzumab products
- Do not substitute Herceptin Hylecta for or with ado-trastuzumab emtansine
- Dose is 600 mg/10,000 units: 600 mg trastuzumab and 10,000 units hyaluronidase administered subcutaneously over 2-5 minutes q3 weeks
- No loading dose required
- No dose adjustments for patient weight or for different concomitant chemotherapy regimens required

Kadcyla (ado-trastuzumab emtansine)

- Approved February 2013
- A HER2-targeted antibody-drug conjugate which contains the humanized anti-HER2 IgG1, trastuzumab, covalently linked to the microtubule inhibitory drug DM1, a maytansine derivative via the stable thioether linker MCC
- Emtansine refers to the MCC-DM1 complex

Mechanism of Action

- HER2-targeted antibody-drug conjugate
- The small molecule cytotoxin, DM1, is a microtubule inhibitor
- Upon binding to HER2 receptor, ado-trastuzumab emtansine undergoes receptor-mediated internalization and subsequent lysosomal degradation, resulting in intracellular release of DM1-containing cytotoxic catabolite
- Binding of DM1 to tubulin disrupts microtubule networks in the cell, which results in cell cycle arrest and apoptotic cell death



Indications and Usage

- Single agent, for the treatment of patients with HER2-positive, metastatic breast cancer who previously received trastuzumab and a taxane, separately or in combination
- Adjuvant treatment for HER2-positive early breast cancer with residual invasive disease after neoadjuvant treatment
    - Versus Trastuzumab in KATHERINE Trial

Dosage and Administration

- Dose: 3.6 mg/kg IV q3 weeks, 21-day cycle until disease progression or unacceptable toxicity
- First infusion: Administer infusion over 90 minutes
    - Patients should be observed during the infusion and for ≥ 90 minutes following the initial dose for fever, chills, or other infusion related reactions
- Subsequent infusions: Administer over 30 minutes if prior infusions were well tolerated
    - Patients should be observed during the infusion and for ≥ 30 minutes after infusion
- Administer as intravenous infusion only with a 0.22 micron in-line non-protein adsorptive polyethersulfone (PES) filter

Do not administer as an intravenous push or bolus

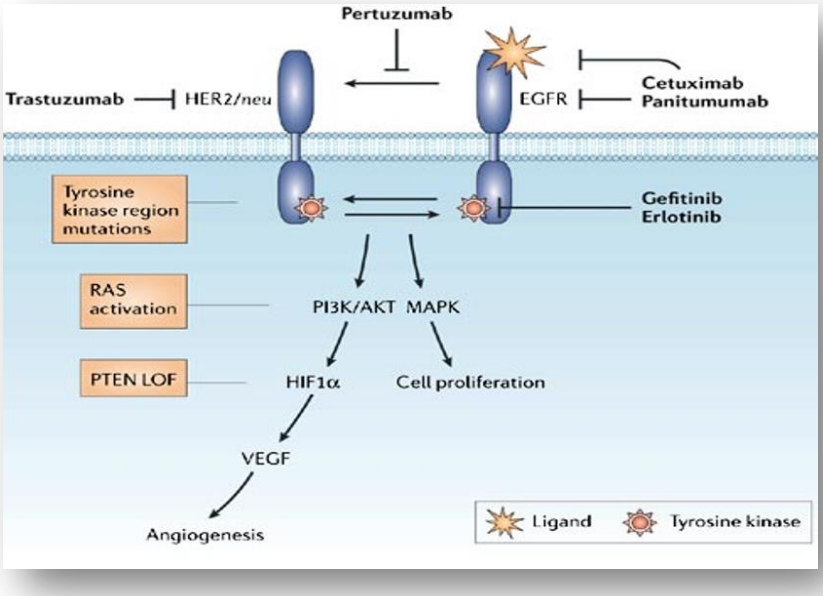
- Infusion bag must contain 250 mL of 0.9% sodium chloride Injection
    - Do not use 5% dextrose in water solution

Warnings and Precautions

- Do not substitute for or with trastuzumab
- Hepatotoxicity, liver failure and death have occurred
    - Monitor hepatic function prior to initiation and prior to each dose. Institute dose modifications or permanently discontinue as appropriate.
- May lead to reductions in LVEF
    - Assess LVEF prior to initiation: Monitor and withhold dosing or discontinue as appropriate.
- Can cause fetal harm

Perjeta (pertuzumab)

- Recombinant humanized monoclonal antibody that targets the extracellular dimerization domain, subdomain II of HER2
- Blocks ligand-dependent heterodimerization of HER2 with other HER family members (EGFR, HER3, HER4)
- Inhibits ligand-initiated intracellular signaling through two major signal pathways, mitogen-activated protein (MAP) kinase and phosphoinositide 3-kinase (PI3K)
    - Inhibiting these signaling pathways can result in cell growth arrest and apoptosis, respectively
- Mediates antibody-dependent cell-mediated cytotoxicity



Indication

- HER2/neu receptor antagonist indicated in combination with trastuzumab and docetaxel for the treatment of patients with HER2-positive metastatic breast cancer who have not received prior anti-HER2 therapy or chemotherapy for metastatic disease
- Treatment of patients with HER2-positive early stage breast cancer prior to surgery who are at high risk for recurrence or metastasis. Used in combination with trastuzumab and chemotherapy
- For IV use only
    - Do not administer IV push or bolus
- Initial dose is 840 mg IV over 60 minutes, followed q3 weeks thereafter by 420 mg IV over 30 to 60 minutes
- Dilute in 250 mL 0.9% sodium chloride ONLY: DO NOT USE 5% dextrose in water

Warnings and Precautions

- LVEF: Monitor LVEF and withhold dosing as appropriate
- Infusion-associated reactions, hypersensitivity reactions/anaphylaxis
- Observe patient for 30-60 minutes after each pertuzumab infusion and before subsequent infusions of trastuzumab or docetaxel
- HER2 testing: Perform using FDA-approved tests by labs with demonstrated proficiency

Vascular endothelial growth factor (VEGF)-Directed Monoclonal Antibodies

Avastin (bevacizumab)

- Approved in 2004
- Humanized IgG1 monoclonal antibody

Indications

- Metastatic colorectal cancer, used in combination with 5-FU based therapy: First or second line
- Combination with carboplatin and paclitaxel with unresectable, locally advanced, recurrent or metastatic non-squamous Non-small cell lung cancer (NSCLC)
- Glioblastoma multiforme of brain, recurrent, progressive disease following prior therapy
- Metastatic renal cell carcinoma in combination with Interferon alpha-2a
- Metastatic, recurrent or persistent cervical cancer with paclitaxel and cisplatin, or with paclitaxel and topotecan
- Platinum-resistant, recurrent epithelial, ovarian, fallopian tube or primary peritoneal cancer in combination with paclitaxel, pegylated liposomal doxorubicin or topotecan
- Platinum-sensitive, recurrent ovarian, in combination with carboplatin and paclitaxel or in combination with carboplatin and gemcitabine, followed by single agent bevacizumab
- For use with chemotherapy, followed by single agent bevacizumab, for treatment of advanced ovarian cancer who underwent initial surgical resection

Mechanism of Bevacizumab

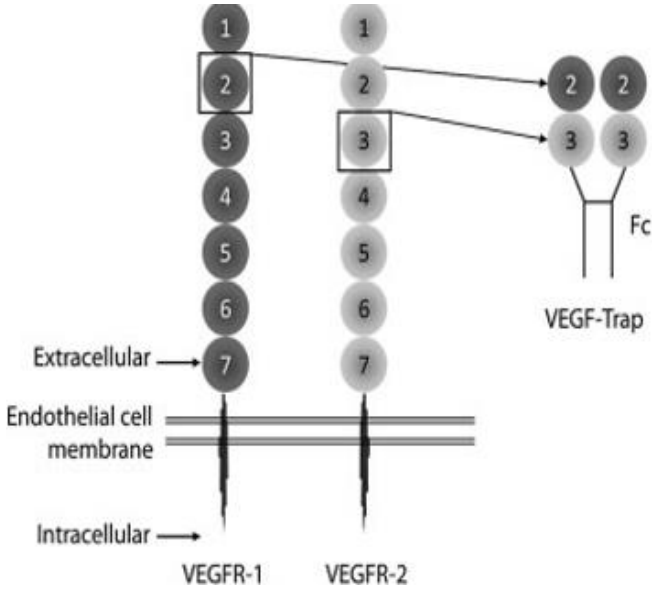
- Binds to VEGF and inhibits the interaction of VEGF to Flt1 and KDR receptors on surface of endothelial cells
- Prevents proliferation of endothelial cells and formation of new blood vessels
    - Blocks angiogenesis

Warnings and Precautions

- GI perforation
    - Abdominal pain, constipation, vomiting
- Wound healing complications
    - Discontinue bevacizumab around elective surgery: 28 days prior
- Hemorrhage
    - Hemoptysis NSCLC, trials
- Severe hypertension
- Proteinuria: Mild to moderate
    - Irreversible increases in urinary protein levels
- Reversible posterior leukoencephalopathy syndrome (RPLS)

Dosing

- Weight based dosing
    - 5 mg/kg, 7.5 mg/kg, 10 mg/kg, 15 mg/kg
    - Most regimens q2 weeks or q3 weeks
- IV: Infuse the initial dose over 90 minutes
    - The second infusion may be administered over 60 minutes if the initial infusion is well tolerated
    - The third and subsequent infusions may be administered over 30 minutes if the 60-minute infusion is well tolerated
- Do not mix in D5W



Zaltrap (ziv-Aflibercept VEGF Trap)

- Approved August 2012
- Recombinant fusion protein consisting of VEGF-binding portions from the extracellular domains of human VEGF Receptors 1 and 2 fused to the Fc portion of human IgG1

Mechanism of Action

- Soluble receptor that binds to human VEGF-A, VEGF-B, and human PlGF, placental growth factor, to prevent receptor binding/activation
- Results in decreased neovascularization and decreased vascular permeability

Indication

- Used in combination with folinic acid, fluorouracil, and irinotecan (FOLFIRI)
- Indicated for metastatic colorectal cancer that is resistant to or has progressed following an oxaliplatin-containing regimen

Dosage and Administration

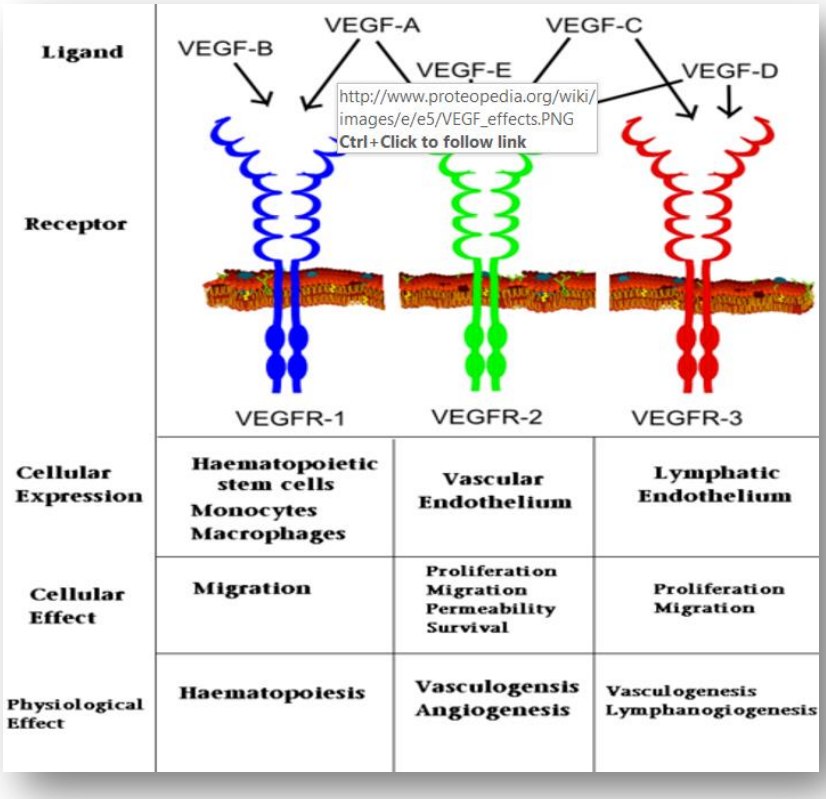
- 4 mg/kg IV over 1-hour q2 weeks
- Give prior to any component of the FOLFIRI regimen on the day of treatment
- Dilute in 0.9% sodium chloride or 5% dextrose in water
    - Final concentration: 0.6- 8 mg/mL

Warnings and Precautions

- Hemorrhage
  - Monitor for GI bleed or other severe bleeding
- GI Perforation
- Wound healing impairment
  - Suspend ≥ 4 weeks prior to elective surgery and do not resume for ≥ 4 weeks following major surgery and until would is healed
- Hypertension: Monitor BP every 2 weeks or more frequently as clinically indicated
- Proteinuria: Monitor urine dipstick and urine protein creatinine ratio (UPCR) for development or worsening of proteinuria
  - Obtain 24-hour urine collection if UPCR > 1

Cyramza (ramucirumab)

- Approved April 2014
- Recombinant human IgG1 monoclonal antibody that binds to VEGFR2 and blocks binding of VEGFR ligands VEGF-A, VEGF-C, VEGF-D
- Inhibits proliferation and migration of endothelial cells and inhibits angiogenesis



Indications

- Advanced gastric cancer or gastro-esophageal junction (GEJ) adenocarcinoma
  - Single agent after prior fluoropyrimidine- or platinum-containing chemotherapy
- In combination with paclitaxel for advanced gastric or GEJ cancer
- Non-small cell lung cancer, metastatic, in combination with docetaxel after progression on or after platinum-based chemotherapy
- Combination with FOLFIRI for treatment of metastatic colorectal cancer (mCRC) whose disease has progressed on a first line bevacizumab-, oxaliplatin- and fluoropyrimidine-containing regimen

Dose

- Dosing: 8-10 mg/kg IV over 60 minutes q2 weeks to q3 weeks (depending on regimen)
  - NOT for IV push or bolus
  - If tolerated, may administer subsequent infusions over 30 minutes
- Pre-medication
  - H1 antagonist (diphenhydramine)
  - If grade 1 or 2 reaction, also give dexamethasone and acetaminophen
- 100 mg/10 mL and 500 mg/50 mL vials
- Dilute in 0.9% sodium chloride to final volume of 250 mL
- DO NOT USE 5% dextrose in water
- Do not freeze or shake
- Use 0.22-micron filter in IV tubing
- Flush line

Warnings and Precautions

- Hemorrhage
- Arterial thromboembolic events
- Hypertension
  - Interrupt until controlled
- Infusion reactions
  - Reduce rate for grade 1/2
  - Permanently discontinue for grade 3/4
- GI Perforations
- Impaired wound healing
- Proteinuria
  - Interrupt for protein $\geq$ 2 g/24 hrs
  - Restart at 6 mg/kg every 2 weeks once returns to < 2 g/24 hrs
  - If reoccurs, interrupt and reduce to 5 mg/kg
  - Discontinue for level > 3 g/24 hrs or nephrotic syndrome
- RPLS

Monoclonal Antibodies that impact the role of VEGF are known to cause which of the following?

A. Colitis
B. Wound Healing
C. Rash
D. Tumor Lysis Syndrome

EGFR-Directed Monoclonal Antibodies

Erbitux (cetuximab)

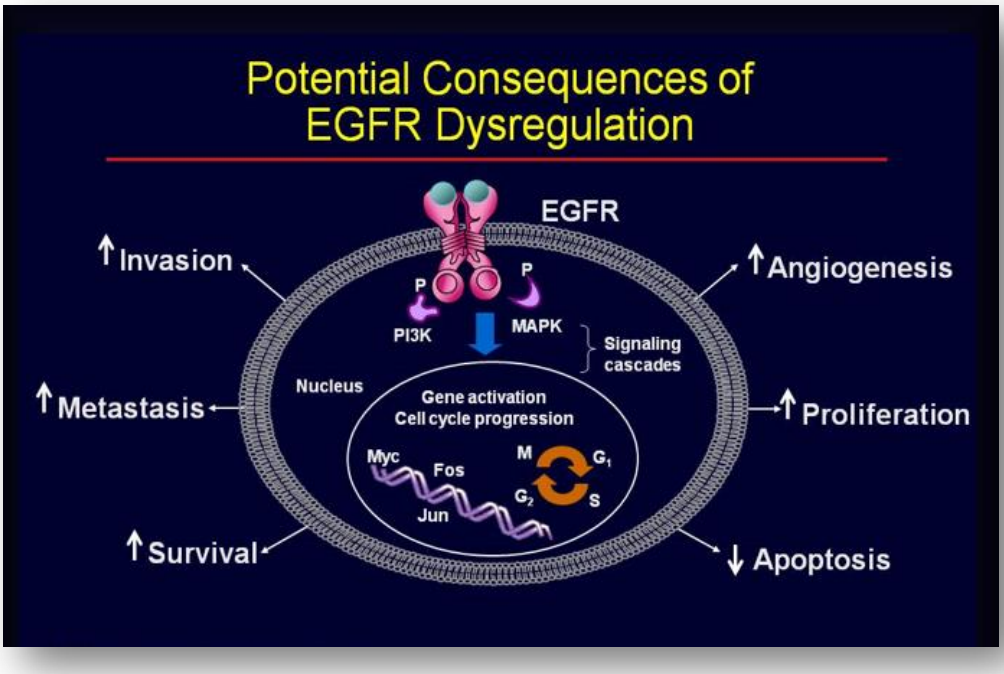
- Approved in 2004
- Chimeric IgG1 monoclonal antibody
- Indications
  - Head and neck cancer
  - Colorectal cancer

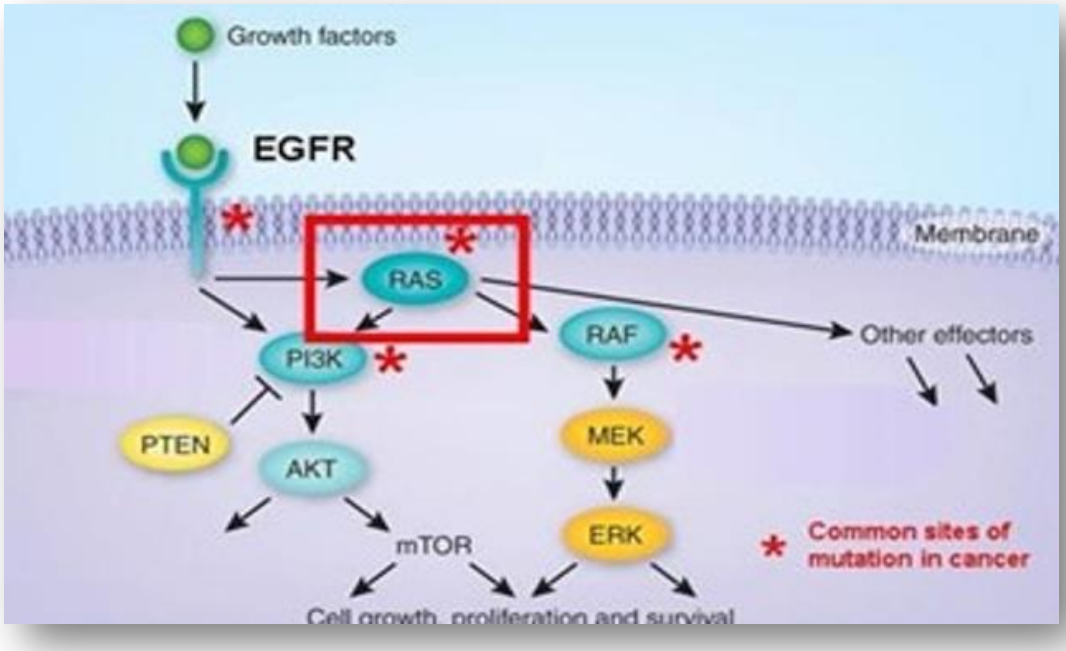
Indications

- Head/neck cancer, locally or regionally advanced squamous cell, in combination with radiation
- Head/neck cancer, metastatic or recurrent squamous cell, refractory to platinum-based therapy as monotherapy
- Head/neck cancer, metastatic, in combination with chemotherapy (cisplatin or carboplatin and 5-fluorouracil)
- Metastatic colorectal cancer, KRAS mutation-negative, EGFR-expressing, as monotherapy, in patients intolerant to irinotecan-based chemotherapy
- Metastatic colorectal cancer, KRAS mutation-negative, EGFR-expressing, as monotherapy in patients who failed both irinotecan- and oxaliplatin-based regimens
- Metastatic colorectal cancer, KRAS mutation-negative, EGFR-expressing, in combination with irinotecan, in patient's refractory to irinotecan-based chemotherapy
- Newest: Metastatic colorectal cancer, K-Ras mutation-negative, EGFR-expressing, first-line therapy, in combination with FOLFIRI (irinotecan, 5-fluorouracil, and leucovorin)

Mechanism of Cetuximab

- Binds to EGFR and blocks growth factor binding and receptor activation
- Blocks phosphorylation and activation of receptor-associated kinases
  - Inhibits growth and survival of tumor cells that over-express EGFR


Potential Consequences of
EGFR Dysregulation
EGFR
Invasion
Angiogenesis
P
P
PI3K
MAPK
Signaling
cascades
Nucleus
Gene activation
Cell cycle progression
Metastasis
Proliferation
Myc
Fos
Jun
M
G1
G2
S
Survival
Apoptosis


Growth factors
EGFR
Membrane
RAS
RAF
Other effectors
PI3K
PTEN
AKT
MEK
ERK
mTOR
Common sites of
mutation in cancer
Cell growth, proliferation and survival

Warnings and Precautions

- Infusion related reactions
  - Observe patient for 1 hour after infusion
  - Pre-medication
    - Diphenhydramine 50 mg IV, 30-60 minutes prior to the first dose
    - Pre-medication for subsequent doses is based on clinical judgement with consideration of reaction to the initial infusion
- Acneiform rash
- Pulmonary toxicity
- Electrolyte abnormalities
  - Monitor Mg, K, and Ca weekly during treatment and for $\geq$ 8 weeks after completion
- Cardiopulmonary arrest
  - Occurred in patients with squamous cell carcinoma of the head and neck receiving cetuximab with radiation therapy or a cetuximab product with platinum-based therapy and fluorouracil

Dose

- Loading dose: 400 mg/m^2 IV over 120 min
- Maintenance: 250 mg/m^2 IV over 60 min
- Administer 1 hour before radiation
- IV infusion through low protein-binding in-line filter
- Flush with NSS before/after infusion

Dose Adjustments

- Acneiform rash
  - Hold for 1-2 weeks and restart at
    - First: Normal
    - Second: 200 mg/m^2
    - Third: 150 mg/m^2
    - Fourth/no improvement: Discontinue
    - Interstitial lung disease: Discontinue

Vectibix (panitumumab)

- Approved in 2006
- Humanized IgG2 monoclonal antibody
- Dose: 6 mg/kg IV over 60 minutes q2 weeks
  - Infuse doses > 1000 mg over 90 minutes
- Indications
  - Metastatic colorectal cancer, EGFR expressing, progress on or following fluoropyrimidine, oxaliplatin, and irinotecan containing therapy
  - Combination with FOLFOX for patients with Wild-Type KRAS Metastatic colorectal cancer

Which of the following is a major side effect to monitor and prevent regarding mAbs targeting EGFR?

A. Colitis
B. Rash
C. Tumor Lysis Syndrome
D. Hypertension

RANKL-Directed Monoclonal Antibodies

Xgeva (denosumab)

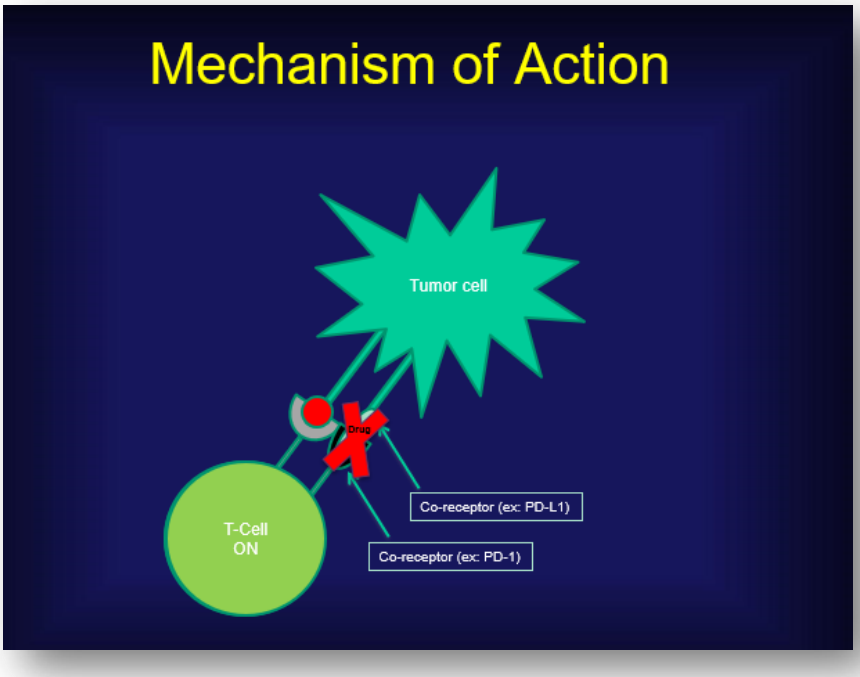
- Approved 2010
- Fully human monoclonal antibody
- Receptor activator of nuclear factor kappa-B ligand (RANKL) inhibitor
- Binds to transmembrane or soluble protein RANKL on the surface of osteoclasts preventing receptor activation
- Formation, function, and survival of osteoclasts are inhibited leading to decreased bone resorption and increased bone mass and strength in the cortical and trabecular bone
- Correct hypocalcemia prior to initiation of denosumab
- Supplement calcium 1000 mg PO QD and vitamin D $\geq$ 400 IU PO QD
- Dental exam prior to and during treatment to monitor for osteonecrosis of the jaw

Indications

- Prevention of skeletal-related events in patients with bone metastases from solid tumors and multiple myeloma
- Improve bone mass among patients at high risk for fracture who receive androgen deprivation therapy for non-metastatic prostate cancer or adjuvant aromatase inhibitor therapy for breast cancer
- Treatment of hypercalcemia of malignancy refractory to bisphosphonate therapy
- Bone metastases/multiple myeloma: Prevention of skeletal related events (Xgeva)
    - Administer 120 mg SQ q4 weeks
    - Upper arm, upper thigh, or abdomen
- Hypercalcemia of malignancy: Xgeva
    - Administer 120 mg SQ q4 weeks
    - During the first month, give an additional 120 mg on days 8 and 15
    - Upper arm, upper thigh, or abdomen
- Improve bone mass: Prolia
    - Administer 60 mg SQ q6 months

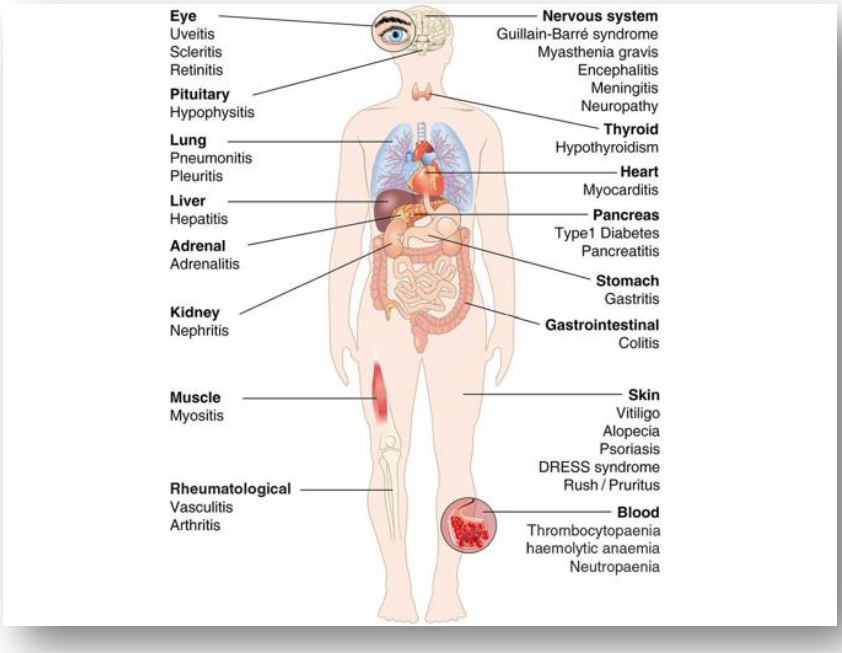
Checkpoint Inhibitors: PD-1/PD-L1 Inhibitors

- Binding of the PD-1 ligands, PD-L1 and PD-L2, to the PD-1 receptor found on T cells, inhibits T cell proliferation and cytokine production
- Upregulation of PD-1 ligands occurs in some tumors and signaling through this pathway can contribute to inhibition of active T cell immune surveillance of tumors



Warnings and Precautions

Immune-mediated adverse reactions



FDA Approved PD-1/PD-L1 Inhibitors

- PD-1 Inhibitors
  - Pembrolizumab; 2014
  - Nivolumab: 2014
  - Cemiplimab: 2018
- PD-L1 Inhibitors
  - Atezolizumab: 2016
  - Avelumab: 2017
  - Durvalumab: 2017

Human Programmed Death Receptor-1 (PD-1) Blocking Antibodies

Keytruda (pembrolizumab) Dosing

- 200 mg IV over 30 minutes q3 weeks
- Mix in 0.9% sodium chloride IV to final concentration of 1-10 mg/mL
- Use IV tubing with 0.2 micron in-line filter

Opdivo (nivolumab) Dosing

- 3 mg/kg IV infusion over 30 minutes q2 weeks
- NEW: Fixed 240 mg (q2 weeks) or 480 mg (q4 weeks)
- Mix in IV 0.9% sodium chloride or 5% Dextrose in Water to final concentration of 1 – 10 mg/mL
- Use IV tubing with 0.2 micron or 1.2 micron in-line filter
- Flush line at end of infusion

Libtayo (Cemiplimab) dosing

- 350 mg IV over 30 minutes q3 weeks until disease progression or unacceptable toxicity
- Infuse through a 0.2 to 5 micron inline or add-on filter
- Allow solution to reach room temperature prior to infusion
- Monitor for infusion reactions

Tecentriq (atezolizumab) dosing

- 1200 mg IV over 60 minutes q3 weeks until disease progression or unacceptable toxicity
- If first infusion tolerated, may infuse all doses over 30 minutes
- Dilute in 250 mL 0.9% sodium chloride only
- Do not administer as IV push

Bavencio (avelumab) Dosing

- 10 mg/kg IV over 60 minutes q2 weeks until disease progression or unacceptable toxicity
- Premedicate with antihistamine and acetaminophen prior to the first 4 infusions
- Pre-medication should be administered for subsequent doses based upon clinical judgment and presence/severity of prior infusion reactions

Imfinzi (durvalumab) Dosing

- 10 mg/kg IV over 60 minutes q2 weeks until disease progression or unacceptable toxicity
- IV bag of 0.9% sodium chloride Injection or 5% dextrose injection
- Do not shake the solution
- Final concentration = 1-15 mg/mL

Pembrolizumab Indications

- Treatment for unresectable or metastatic melanoma and disease progression following ipilimumab and, if BRAF V600 mutation positive, a BRAF inhibitor
- Initial treatment of unresectable or metastatic melanoma
- Head and neck cancer, recurrent or metastatic, squamous cell, with disease progression on or after platinum-based chemotherapy
- Second line use for locally advanced or metastatic urothelial carcinoma who have experienced disease progression during or following platinum-containing chemotherapy or within 12 months of neoadjuvant or adjuvant treatment with platinum-containing chemotherapy
- Metastatic NSCLC whose tumors have high PD-L1 expression with no EGFR or ALK genomic tumor aberrations, and no prior systemic chemotherapy treatment for metastatic NSCLC
- Metastatic NSCLC whose tumors express PD-L1 with disease progression on or after platinum-containing chemotherapy
    - Patients with EGFR or ALK genomic tumor aberrations should have disease progression on FDA-approved therapy for these aberrations
- First-line combination therapy with pemetrexed and carboplatin to treat metastatic NSCLC regardless of PD-L1 expression
- Adult and pediatric patients with unresectable or metastatic, microsatellite instability-high (MSI-H) or mismatch repair deficient (dMMR) solid tumors that have progressed following prior treatment and who have no satisfactory alternative treatment options
- MSI-H or dMMR colorectal cancer that has progressed following treatment with a fluoropyrimidine, oxaliplatin, and irinotecan
- Recurrent locally advanced or metastatic, gastric or gastroesophageal junction adenocarcinoma whose tumors express PD-L1 as determined by an FDA-approved test
    - Must have had disease progression on or after $\geq$ 2 prior systemic therapies, including fluoropyrimidine- and platinum-containing chemotherapy and, if appropriate, HER2/neu-targeted therapy
- Women with PD-L1-expressing recurrent or metastatic cervical cancer who progressed on or after chemotherapy
- Adult and pediatric patients with refractory PMBCL, or who have relapsed after $\geq$ 2 prior lines of therapy
- First line for metastatic squamous NSCLC in combination with carboplatin and either paclitaxel or nab-paclitaxel
- Hepatocellular carcinoma (HCC) previously treated with sorafenib
- Recurrent locally advanced or metastatic Merkel cell carcinoma

- Adjuvant treatment in melanoma with lymph node involvement who had complete resection
- Metastatic SCLC that progressed on or after platinum-based therapy and at least one other prior line of therapy

Nivolumab Indications

- Unresectable or metastatic melanoma and disease progression following ipilimumab and, if BRAF V600 mutation positive, a BRAF inhibitor
- Metastatic squamous non–small-cell lung cancer (NSCLC) in patients who have progressed on platinum-based chemotherapy
- Combination of nivolumab plus ipilimumab for treatment of *BRAF V600* wild-type unresectable or metastatic melanoma
- Advanced renal cell carcinoma after prior antiangiogenic therapy
- A single-agent frontline treatment for patients with *BRAF* wild-type advanced melanoma
- Hodgkin lymphoma that has relapsed or progressed after autologous stem cell transplant and post-transplantation brentuximab vedotin
- Recurrent or metastatic squamous cell carcinoma of the head and neck with disease progression on or after a platinum-based therapy
    - Locally advanced or metastatic urothelial carcinoma who have disease progression during or following platinum-containing chemotherapy, have disease progression within 12 months of neoadjuvant or adjuvant treatment with platinum-containing chemotherapy
- MSI-H or MMR metastatic colorectal cancer that has progressed following treatment with a fluoropyrimidine, oxaliplatin, and irinotecan
- HCC previously treated with sorafenib
- Adjuvant treatment of patients with melanoma who have involved lymph nodes or metastatic disease and who underwent complete resection
    - This approval includes patients with mutated and wild-type *BRAF*
- Nivolumab and ipilimumab for the treatment of intermediate- or poor-risk patients with previously untreated advanced renal cell carcinoma
- Nivolumab + ipilimumab for MSI-H or dMMR metastatic colorectal cancer that progressed following treatment with a fluoropyrimidine, oxaliplatin, and irinotecan
- Newest: Metastatic small cell lung cancer who progressed after platinum-based chemotherapy and at least one other line of therapy

Atezolizumab Indications

- Initial treatment of locally advanced or metastatic urothelial carcinoma who are not eligible for cisplatin chemotherapy
- Locally advanced or metastatic urothelial carcinoma
    - Have disease progression during or following platinum-containing chemotherapy
    - Have disease progression within 12 months of neoadjuvant or adjuvant treatment with platinum-containing chemotherapy
- In combination with bevacizumab, paclitaxel, and carboplatin, for first-line treatment of metastatic non-squamous NSCLC without EGFR or ALK mutations
- Previously treated metastatic NSCLC after disease progression
- First-line treatment of unresectable locally advanced or metastatic, PD-L1 positive TNBC with nab-paclitaxel
- Extensive stage SCLC for first-line treatment with carboplatin and etoposide
- Adult and pediatric patients $\geq$ 12 years with metastatic Merkel cell carcinoma
- Locally advanced or metastatic urothelial carcinoma whose disease progressed during or following platinum-containing chemotherapy or within 12 months of neoadjuvant or adjuvant platinum-containing chemotherapy

Durvalumab Indications

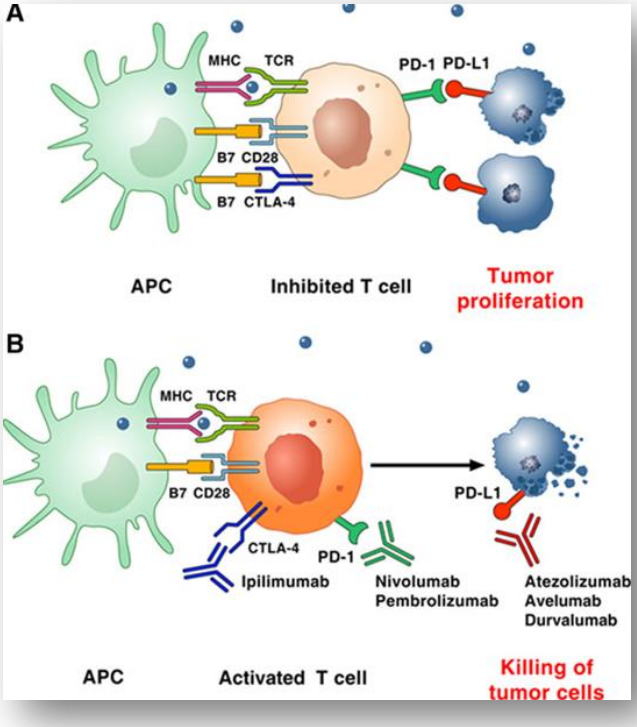
- Patients with locally advanced or metastatic urothelial carcinoma who
    - Disease progression during or following platinum-containing chemotherapy
    - Disease progression within 12 months of neoadjuvant or adjuvant treatment with platinum-containing chemotherapy

Cemiplimab Indications

- Treatment of metastatic cutaneous squamous cell carcinoma (CSCC)
- Locally advanced CSCC in patients who are not candidates for curative surgery or curative radiation

Checkpoint Inhibitors: CTLA-4 Inhibitors

Mechanism



Yervoy (ipilimumab)

- Fully human antibody (IgG1 kappa) that binds and blocks cytotoxic T lymphocyte-associated antigen 4 (CTLA-4) and its ligands, CD80/CD86
- Molecule on T-cells that plays role in regulating natural immune responses. Absence or presence of CTLA-4 can augment or suppress the immune system's T-cell response in fighting disease
- Sustains active immune response
- Augment T-cell activation and proliferation

Indications

- Advanced melanoma unresectable or metastatic, that has been previously treated
- Combination of nivolumab plus ipilimumab for treatment of patients with BRAF V600 wild-type unresectable or metastatic melanoma
- Adjuvant treatment after complete resection of cutaneous melanoma with lymph node involvement
- Nivolumab and ipilimumab for the treatment of intermediate- or poor-risk patients with previously untreated advanced renal cell carcinoma
- Nivolumab + ipilimumab for MSI-H or dMMR metastatic colorectal cancer that progressed following treatment with a fluoropyrimidine, oxaliplatin, and irinotecan

Dose

- 3 mg/kg IV over 90 minutes
  - 1 mg/kg or 10 mg/kg
- Dilute with 0.9% sodium chloride or 5% dextrose in water
- Final concentration = 1-2 mg/mL
- Use low-protein binding in-line filter
- Flush line after dose

Adverse Reactions

- Immune-mediated reactions
  - Enterocolitis
  - Hepatitis
  - Dermatitis
  - Neuropathies
  - Endocrinopathies
  - Ocular manifestations
- Infusion reactions: <1%

Monitoring

- LFTs and bilirubin at baseline and each dose
- Thyroid function tests at baseline and each dose
- Serum chemistries and adrenocorticotropic hormone (ACTH) prior to each dose
- Serum creatinine: Baseline and periodic
- Diarrhea, abdominal pain, blood/mucus in stool
- Rash, pruritus, other signs of dermatologic toxicity
- Other immune-mediated endocrinopathies

Which of the following should be monitored during treatment with CTLA-4 and/or PD-1/PD-L1 mAbs?

A. TSH
B. ALT/AST
C. Cortisol
D. All the above

CD30-Directed Monoclonal Antibodies

Adcetris (brentuximab vedotin)

- Chimeric IgG1 monoclonal antibody-drug conjugate targeting CD30
- Expressed by Reed-Sternberg cells specific to Hodgkin Lymphoma
- May control apoptosis, cell activation, and proliferation

Indications

- Hodgkin lymphoma (HL) after failure of autologous stem cell transplant (ASCT) or after failure of ≥ 2 prior multi-agent chemotherapy regimens in patients who are not ASCT candidates
- Systemic anaplastic large cell lymphoma after failure of ≥ 1 prior multi-agent chemotherapy regimen
- HL: Consolidation therapy after ASCT
- Front-line with chemotherapy (AVD) in patients with stage III/IV HL
- Adult patients with previously untreated systemic anaplastic large cell lymphoma (sALCL) or other CD30-expressing peripheral T-cell lymphomas (PTCL), including angioimmunoblastic T-cell lymphoma and PTCL not otherwise specified, in combination with cyclophosphamide, doxorubicin, and prednisone

Mechanism of Action

- Binds to CD30 on the Reed-Sternberg cell
- Cancer cell then internalizes and releases MMAE
    - MMAE: Microtubule disrupting agent
        - Binds tubulin and disrupts the microtubule network with the cell
        - G2/M cell cycle arrest leading to apoptosis
- Handle as chemotherapy

Dose and Schedule

- 1.8 mg/kg IV infusion over 30 minutes q3 weeks
- Do not administer as an IV push or bolus
- Continue treatment until disease progression or unacceptable toxicity
- Consolidation: Up to 16 cycles
- Dose for patients > 100 kg should be calculated for 100 kg
- IV bag should contain minimum volume of 100 mL
- Final concentration: 0.4-1.8 mg/mL
- Dilute in IV bag containing 0.9% sodium chloride, 5% dextrose in water, or Lactated Ringer's solution

Monitoring

- Infusion reactions
    - If occur, premedicate with acetaminophen, antihistamine, and corticosteroid
- TLS
- Drug interactions
    - MMAE is a substrate and an inhibitor of CYP3A4/5

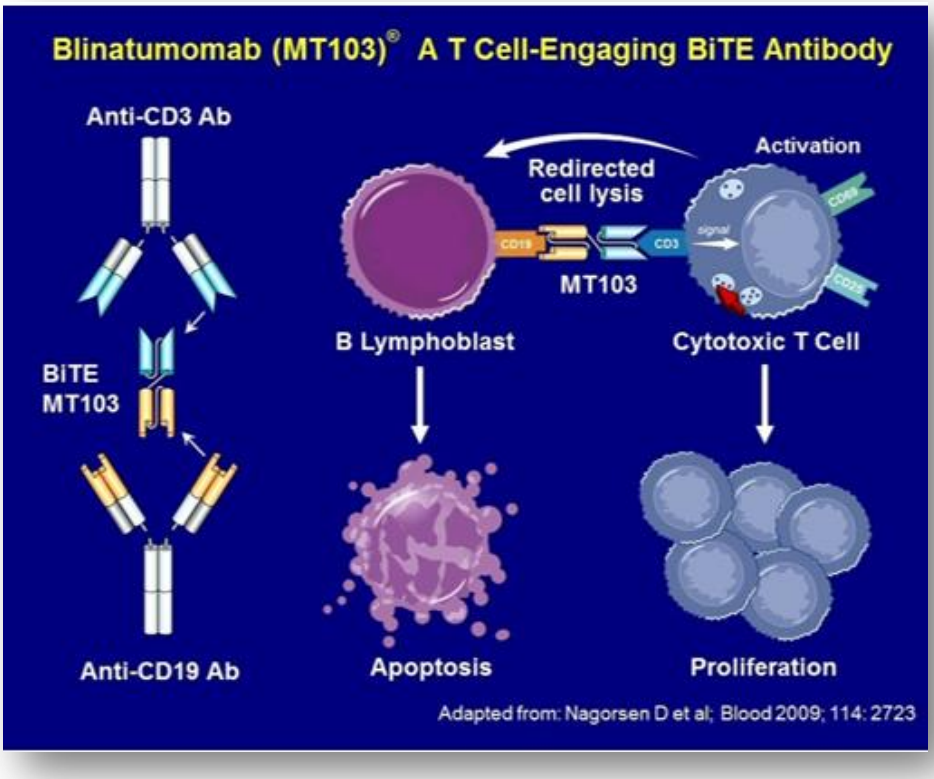
Bi-Specific T-cell Engagers (BiTEs)

Blincyto (blinatumomab)

- Approved in December 2014
- Bispecific CD19 directed CD3 T-cell engager
- Treatment of relapsed or refractory B-cell precursor acute lymphoblastic leukemia (ALL) in adults and children
    - Includes both Philadelphia chromosome positive and negative relapsed or refractory B-cell precursor ALL
- B-cell precursor ALL in first or second complete remission with minimal residual disease (MRD) ≥0.1% in adults and children

Mechanism of Action

- Binds to CD19 expressed on the surface of B cells and CD3 expressed on the surface of T-cells
- Activates endogenous T cells by connecting CD3 in the T-cell receptor (TCR) complex with CD19 on benign and malignant B cells
- Mediates the formation of a synapse between the T cell and the tumor cell, upregulation of cell adhesion molecules, production of cytolytic proteins, release of inflammatory cytokines, and proliferation of T cells, which result in redirected lysis of CD19+ cells



Dosage and Administration

Relapse/Refractory (R/R) B-cell ALL

- Hospitalization is recommended for the first 9 days of cycle 1, and the first 2 days of cycle 2
- B-cell ALL, MRD-positive ≥ 0.1%: Hospitalization is recommended for the first 3 days of cycle 1, and the first 2 days of cycle 2
- For all subsequent cycle starts and re-initiation e.g., if treatment is interrupted for 4 or more hours, supervision by a healthcare professional or hospitalization is recommended
- Do not flush the infusion line especially when changing infusion bags
    - Flushing when changing bags or at completion of infusion can result in excess dosage and complications
- Cycle: 4 weeks of continuous intravenous infusion followed by a 2-week treatment-free interval, extend to 8-week treatment-free interval for cycles 6-9
- Therapy involves up to 2 induction cycles followed by 3 additional cycles for consolidation and up to 4 additional cycles of continued therapy (total of up to 9 cycles)
- Patients ≥ 45 kg: fixed dose
    - During cycle 1, administer 9 mcg/day on days 1-7 and 28 mcg/day on days 8-28
    - For subsequent cycles, administer 28 mcg/day on Days 1-28
- Patients <,45 kg: dose based on BSA
    - Cycle 1: 5 mcg/m2/day: maximum: 9 mcg/day administered on days 1-7, followed by 15 mcg/m2/day (maximum: 28 mcg/day) on days 8-28
    - For subsequent cycles, administer 15 mcg/m2/day: maximum: 28 mcg/day on days 1-28

Dosage MRD B-cell ALL

- Cycle: 4 weeks of continuous intravenous infusion followed by a 2-week treatment-free interval
- Therapy involves 1 induction cycle followed by up to 3 additional cycles for consolidation: Total of up to 4 cycles
    - Can proceed to transplant, if eligible, after cycle 1
- Patients ≥ 45 kg: fixed dose
    - Cycles 1 to 4: 28 mcg daily administered as a continuous infusion on days 1-28
- Patients <45 kg: Dose based on BSA
    - Cycles 1 to 4: 15 mcg/m2/day, maximum: 28 mcg/day as a continuous infusion on days 1-2

Administration

- Premedicate with dexamethasone 16-20 mg IV 1 hour prior to first dose of each cycle, prior to a step dose: such as cycle 1 day 8, or when restarting infusion after interruption of 4 or more hours
- Infuse solution according to instructions on pharmacy label on the bag at one of the following constant infusion rates
    - 24-hour bag: 10 mL/hr: total 240 mL for 24 hours
    - 48-hour bag: 5 mL/hr total 240 mL for 48 hours
    - 7-day bag: 0.6 mL/hr total 100 mL) for 7 days
- Solution for infusion must be administered using IV tubing that contains a sterile, non-pyrogenic, low protein-binding, 0.2 micron in-line filter
- Do not flush infusion line, especially when changing infusion bags
- Flushing when changing bags or at completion of infusion can result in excess dosage
- Infuse through a dedicated lumen

Warnings and Precautions

- Cytokine release syndrome (CRS)
    - May be life-threatening or fatal
    - Pyrexia, headache, nausea, rash, hypotension, asthenia, increased LFTs, wheezing
- Neurological toxicities
    - May be severe, life-threatening, or fatal
    - Occur in ~66.7% of patients
    - Median time to onset: Within the first two weeks
    - Convulsions, speech disorders, confusion and disorientation, encephalopathy, convulsions, disturbances in consciousness, coordination/balance disorders

CD38-Directed Monoclonal Antibodies

Darzalex (daratumumab)

- Approved in November 2015
- IgG1 kappa human monoclonal antibody against CD38 antigen
    - CD38 is a transmembrane glycoprotein expressed on the surface of hematopoietic cells, including plasma cells
    - Has multiple functions, such as receptor mediated adhesion, signaling, and modulation of cyclase and hydrolase activity

Mechanism of Action

- Binds to CD38 and inhibits the growth of CD38 expressing tumor cells by inducing apoptosis directly through Fc mediated cross linking and by immune-mediated tumor cell lysis through CDC, ADCC, and ADCP
- Myeloid derived suppressor cells (MDSCs) and a subset of regulatory T cells (CD38+Tregs) express CD38 and are susceptible to daratumumab mediated cell lysis

Indications

- Patients with multiple myeloma (MM) who have received ≥ 3 prior lines of therapy
- With lenalidomide/dexamethasone or bortezomib/ dexamethasone, for treatment of patients with MM who have received ≥ 1 prior therapy
- With pomalidomide/dexamethasone for patients who have received ≥ 2 prior therapies, including lenalidomide and a proteasome inhibitor
- Combination with bortezomib, melphalan and prednisone to treat patients with newly diagnosed MM who are ineligible for autologous SCT
- Combination with lenalidomide and dexamethasone in newly diagnosed patients who are ineligible for autologous SCT and in patients with relapsed or refractory MM
- In combination with bortezomib, thalidomide and dexamethasone (VTd) in newly diagnosed adult patients who are eligible for autologous SCT

Dose

- Pre-medicate with corticosteroids, antipyretics and antihistamines
- Administer as an intravenous infusion
    - Infuse using 0.22 micron in-line filter
- Recommended dose is 16 mg/kg body weight
    - Q1 week: Weeks 1 to 8
    - Q2 weeks: Weeks 9 to 24
    - Q4 weeks: Week 25 onwards until progression of disease (PD)
- Consider split dosing for the first dose?
- Administer post-infusion medications

Pre-Infusion Medications

- Administer pre-medications to reduce the risk of infusion reactions approximately one hour prior to every infusion as follows
    - IV corticosteroid: Methylprednisolone 100 mg, or equivalent dose of an intermediate-acting or long-acting corticosteroid, plus oral antipyretics (acetaminophen 650 to 1000 mg), plus oral or intravenous antihistamine (diphenhydramine 25 to 50 mg or equivalent)
    - Following the second infusion, the dose of corticosteroid may be reduced (methylprednisolone 60 mg intravenously)

Post-Infusion Medications

- Administer post-infusion medication to reduce the risk of delayed infusion reactions to all patients as follows
    - Oral corticosteroid (20 mg methylprednisolone or equivalent corticosteroid dose in accordance with local standards) on the first and second day after all infusions
    - For patients with history of obstructive pulmonary disorder, consider prescribing post-infusion medications such as short and long-acting bronchodilators, and inhaled corticosteroids
    - Following the first four infusions, if no major infusion reactions, these additional inhaled post-infusion medications may be discontinued

Prophylaxis for Herpes Zoster Reactivation

- Initiate antiviral prophylaxis to prevent herpes zoster reactivation within 1 week of starting and continue for 3 months following treatment

Warnings and Precautions

- Infusion Reactions
- Interference with serological testing
    - Binds to CD38 on RBCs and results in positive Coombs Test
    - Masks detection of antibodies to minor antigens in serum
    - Notify blood banks
    - May persist for up to 6 months
- Interference with determination of MM response
    - Drug may be detected on SPEP and immunofixation
    - Impact monitoring of M-protein

SLAMF7-Directed Monoclonal Antibodies

Empliciti (elotuzumab)

- Approved in November 2015
- Humanized recombinant monoclonal antibody directed to SLAMF7, a cell surface glycoprotein

Mechanism of Action

- Targets the SLAMF7 protein
    - SLAMF7 is expressed on myeloma cells independent of cytogenetic abnormalities
    - SLAMF7 is also expressed on NK cells, plasma cells, and at lower levels on specific immune cell subsets
- Directly activates NK cells through both the SLAMF7 pathway and Fc receptors
- Targets SLAMF7 on myeloma cells and facilitates the interaction with NK cells to mediate the killing of myeloma cells through ADCC

Indication

- In combination with lenalidomide and dexamethasone for the treatment of patients with MM who received 1-3 prior therapies
- In combination with pomalidomide and dexamethasone for the treatment of MM in patients who received $\geq$ 2 prior therapies, including lenalidomide and a proteasome inhibitor

Dose

- Recommended dose is 10 mg/kg IV q1 week for the first 2 cycles and q2 weeks thereafter in conjunction with the recommended dosing of lenalidomide and low-dose dexamethasone
- Must premedicate prior to each dose with dexamethasone, acetaminophen, an H1 antagonist, and an H2 antagonist
    - On days that elotuzumab is administered, give dexamethasone 28 mg PO between 3 and 24 hours before plus 8 mg IV between 45 and 90 minutes before elotuzumab
    - On days that elotuzumab is not administered but a dose of dexamethasone is scheduled: Days 8 and 22 of cycle 3 and all subsequent cycles, give 40 mg PO

Administration

- Administer using 0.2-1.2 µm in-line filter
- Dilute with 230 mL 0.9% sodium chloride or 5% dextrose in water
    - May adjust volume so as not to exceed 5 mL/kg of patient weight
- Titrate infusion in stepwise fashion
- After receiving 4 cycles, the infusion rate may be increased to a maximum of 5 mL/minute

Warnings and Precautions

- Infusion reactions: Pre-medication is required
- Infections: Monitor for fever and other signs of infection and treat promptly
- Secondary primary malignancies
- Hepatotoxicity
- Interference with determination of complete response: Can interfere with assays used to monitor M-protein
    - This interference can impact the determination of complete response

CD33-Directed Monoclonal Antibodies

Mylotarg (gemtuzumab ozogamicin)

- Approved in September 2017
- Recombinant humanized IgG4 immunoglobulin covalently linked to the cytotoxic agent N-acetyl gamma calicheamicin

Indications

- Newly diagnosed CD33+ AML in adults
- Relapse/refractory CD33-positive AML in adults and pediatric patients $\geq$ 2 years

Mechanism of Action

- A CD33-directed antibody-drug conjugate (ADC)
    - N-acetyl gamma calicheamicin, is a cytotoxic agent that is covalently attached to the antibody via a linker
- Gemtuzumab ozogamicin binds to CD33-expressing tumor cells, resulting in internalization of the antibody-antigen complex
    - Following internalization, the calicheamicin derivative is released inside the myeloid cell
    - The calicheamicin derivative binds to DNA resulting in double strand breaks inducing cell cycle arrest and apoptosis

Warnings and Precautions

- Bone marrow suppression
- Nausea/vomiting: Moderate emetic potential
- Hemorrhage: Prolonged thrombocytopenia
- Hepatotoxicity
    - Box warning for veno-occlusive disease/sinusoidal obstruction syndrome (VOD/SOS)
- Infusion reaction
- QT prolongation
    - Obtain baseline EKG and monitor electrolytes closely
- TLS

CD22-Directed Monoclonal Antibodies

Besponsa (iInotuzumab ozogamicin)

- Approved in August 2017
- Recombinant humanized immunoglobulin class G subtype 4 (IgG4) kappa antibody
- Indicated for adults with relapsed or refractory B-cell precursor acute lymphoblastic leukemia (ALL)

Mechanism of Action

- CD22-directed antibody-drug conjugate (ADC)
- Recognizes CD22 and has N-acetyl-gamma-calicheamicin
    - A cytotoxic agent that is covalently attached to the antibody via a linker
- Binds to CD22-expressing tumor cells, followed by internalization of the ADC-CD22 complex, and the intracellular release of N-acetyl-gamma-calicheamicin dimethylhydrazide via hydrolytic cleavage of the linker

Lumoxiti (moxetumomab pasudotox-tdfk)

- CD22-directed cytotoxin for adult patients with relapse/refractory hairy cell leukemia (HCL) who have received ≥ 2 prior systemic therapies, including treatment with a purine nucleoside analog

Administration

- Recommended dose: 0.04 mg/kg IV over 30 minutes on days 1, 3 and 5 of each 28-day cycle: Up to 6 cycles
- Premedicate 30 to 90 minutes prior to each moxetumomab pasudotox infusion with an antihistamine, acetaminophen, and a histamine-2 receptor antagonist
- Hydration
    - 1000 mL of isotonic solution should be administered over 2-4 hours before and after each infusion of moxetumomab pasudotox-tdfk
        - If the patients weigh < 50 kg, administer 500 mL of isotonic solution
    - Hydrate with ≤ 3 L of PO fluids QD on days 1-8 of each 28-day cycle
        - For patients who weigh < 50 kg, ≤ 2 L should be recommended.
    - Monitor fluid balance and serum electrolytes
- Thromboprophylaxis: Consider low-dose aspirin on days 1-8 of each 28-day cycle

Warnings and Precautions

- Capillary leak syndrome
    - Monitor weight and blood pressure (prior to each infusion and as clinically indicated)
- Electrolyte abnormalities
- Hemolytic uremic syndrome
    - Monitor hemoglobin, platelet count, serum creatinine, and ensure adequate hydration
    - Discontinue moxetumomab pasudotox in patients with HUS
- Infusion reactions
    - Reported in 50% of patients
- Renal toxicity

CD79b-Directed Monoclonal Antibodies

Polivy (olatuzumab vedotin)

- A CD79b-directed antibody–drug conjugate indicated in combination with bendamustine and a rituximab product for the treatment of adult patients with relapsed or refractory DLBCL, not otherwise specified, after ≥ 2 prior therapies

Mechanism of Action

- Upon binding CD79b, polatuzumab vedotin is internalized, and the linker is cleaved by lysosomal proteases to enable intracellular delivery of MMAE
- MMAE binds to microtubules and kills dividing cells by inhibiting cell division and inducing apoptosis

Dose

- Recommended dose: 1.8 mg/kg IV over 90 minutes q21 days for 6 cycles in combination with bendamustine and rituximab
    - Subsequent infusions may be administered over 30 minutes if the previous infusion is tolerated
- Premedicate with an antihistamine and antipyretic

Warnings and Precautions

- Bone marrow suppression
- Hepatotoxicity
- Infection
- Infusion-related reactions
- Peripheral neuropathy
- PML
- TLS

CCR4-Directed Monoclonal Antibodies

Poteligeo (mogamulizumab-kpkc)

- Approved August 2018
- Humanized IgG1 kappa monoclonal antibody that binds to CCR4
- Indicated for the treatment of adult patients with relapse/refractory mycosis fungoides (MF) or Sézary syndrome (SS) after ≥ 1 prior systemic therapy

Mechanism of Action

- Anti-CCR4 first-in-class defucosylated, humanized IgG1 kappa monoclonal antibody

Dosing

- 1 mg/kg IV on days 1, 8, 15, and 22 of cycle 1, followed by 1 mg/kg on days 1 and 15 of each subsequent cycle
    - Continue until disease progression or unacceptable toxicity

Warnings and Precautions

- Autoimmune toxicity
- Bone marrow suppression
- Dermatologic toxicity
    - Rash is one of the most frequently reported
- Infections
- Infusion reactions
    - Most occur during or shortly after the first infusion, but may also occur with subsequent infusions
    - Premedicate prior to the first infusion with diphenhydramine and acetaminophen
- Increased allogeneic stem cell transplant complications i.e. graft versus host disease (GVHD)

IL-6 Receptor-Directed Monoclonal Antibodies

Actemra (tocilizumab)

- Interleukin-6 (IL-6) receptor antagonist
    - Endogenous IL-6 is induced by inflammatory stimuli and mediates a variety of immunological responses
    - Inhibition of IL-6 receptors by tocilizumab leads to a reduction in cytokine and acute phase reactant production
- Dosing in Chimeric Antigen Receptor (CAR)-T related cytokine release syndrome (CRS)
    - Maximum dose: 800 mg IV over 60 minutes
        - < 30 kg: 12 mg/kg
        - ≥ 30 kg: 8 mg/kg
    - If clinical improvement does not occur after the first dose, up to 3 additional doses may be administered (with ≥ 8-hour interval between consecutive doses)
    - May be administered as monotherapy or in combination with corticosteroids

Indications

- Cytokine release syndrome (CRS), severe or life-threatening: Treatment of CAR T-cell induced severe or life-threatening CRS in patients ≥ 2 years of age
- Giant cell arteritis
- Polyarticular juvenile idiopathic arthritis Rheumatoid arthritis
- Systemic juvenile idiopathic arthritis

Warnings and Precautions

- GI perforation
- Hematologic effects
- Hepatic effects
    - Monitor LFTs prior to therapy initiation and during treatment
- Hyperlipidemia
- Hypersensitivity reactions
- Malignancy
- Infections
- Herpes zoster reactivation
- Tuberculosis
    - Both reactivation of latent and new tuberculosis cases
    - Patients should be tested for latent tuberculosis infection before and during therapy

Oral Adherence

Definition

- Extent to which a patient's behavior coincides with medical advice
- Estimates of adherence are between 15-100%
- Same as compliance?
- Measurement
    - Percentage of prescribed doses taken by the patient over a specified timeframe
        - Dose taking: Taking the amount of medication prescribed for a day
        - Dose timing: Taking the medication within the prescribed period

Significance

- There are more than 40 FDA-approved oral agents for cancer treatment
- Nearly ¼ of the agents being researched now are oral compounds
- 125,000 deaths per year are due to non-adherence
- 10-23% of admissions to hospitals/nursing homes due to non-adherence

Non-Adherence

- Not taking enough of the medication

Over-adherence

- Taking too much of the medication
- The "more is better" approach

Measuring Adherence

- Hippocrates actually measured adherence by noting the effects of various potions and whether the patient took them or not

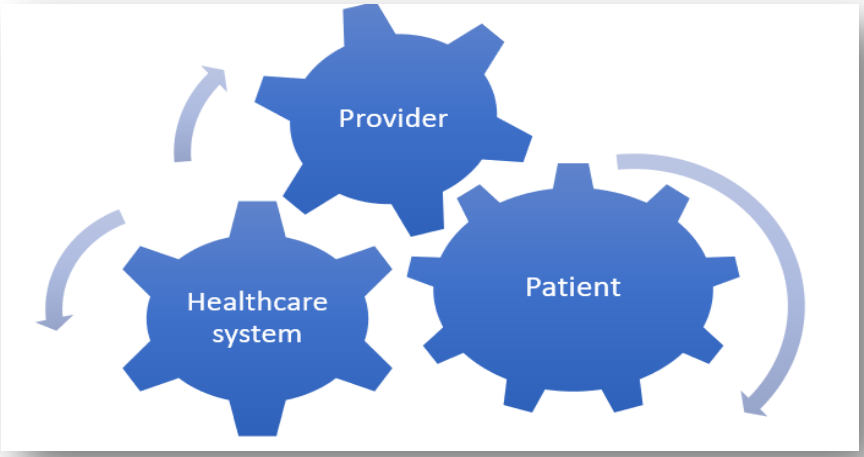
Direct Measures

- Direct observation
    - Most accurate but time consuming and relies on adequate staffing
    - Impractical for routine use: Patients can also hide pills in the buccal cavity
- Measurement of drug levels or biologic markers added to drug formulation
    - Can be altered due to variations in metabolism
    - White coat adherence: Patient is more likely to follow medication schedule when they have a pending appointment or lab values to be drawn

Indirect Measures

- Patient self-report/questionnaire
  - Easy and inexpensive
  - Results easily altered by patient; error-risk increases with longer time between visits
- Pill counts
  - Easy to perform, but can be easily altered by patient
- Prescription refill rate
  - Easy and objective
  - Refilling prescription but not taking the medication
- Clinical response
  - Simple to perform
  - Clinical response may be affected by things other than adherence
- Electronic medication monitor
  - Easily quantified results: Tracks patterns of medication-taking
  - Expensive: Information needs downloaded from medication vials
    - Opening vial but not taking medication
- Physiologic marker measures
  - Useful with other types of medications
  - Easy to perform
  - Other things can affect physiologic response
- Patient diaries
  - Decreases risk of poor memory of taking pills
  - Easily altered by patient
- Caregiver questionnaire
  - Simple can be easily altered

Barriers to Adherence



Impact on Patient Care

- Shift on responsibility
- Benefits of oral therapy
    - Convenient
    - Decreased IV access leads to decrease risk of IV complications
    - Allows patient to be more autonomous
    - Less time spent at clinical/hospital allowing more time for family and work
- Consequences of non-adherence
    - Decreased disease-free survival
    - Inferior treatment outcomes
        - Worsening of disease and/or death
    - Increased physician visits
    - More hospitalizations/longer length of stays
    - Possibility of treatment resistance
    - Over-adherence: Increased adverse effects and drug toxicities

Interventions

- Need to first recognize non-adherence
- Various interventions and strategies
    - Not one has been shown beneficial when used alone
- Should use multiple interventions/strategies to optimize success
- Should be a multi-disciplinary strategy
- Education and communication
- Visual reminders
    - Organizational methods
    - Dispensers
- Proactive management of side effects
- Frequent follow-up
- Motivational interviewing

Education: Patient and Caregiver

- Reason for medication
- Why medication is needed and how it works
- Dosage, frequency, and special instructions for taking the medication
- Is the medication compatible with other medications the patient is taking prescription and nonprescription
- How to handle a missed or late dose
- Common side effects and treatment of those side effects
- When to hold a dose

Organization/Dispensers/Visual Aids

- Calendars
- Pill boxes
- Electronic reminders
    - Timers/alarm clocks
    - Cell phone alerts
    - Telephone reminder services
    - Pagers with text
- Easy-open containers
- Use of medication blister packs
- Labels on bottles with large print

Proactive Side Effect Management

- Education
- Prescriptions for necessary supplemental medications
    - Anti-emetics
    - Laxatives
- Difference between expected side effect and toxicities and complications
- Notification of when to alert physician

Frequent Follow-Ups

- Office visits to ensure understanding of treatment regimen and medication education
- Less complex regimens when feasible
- Telephone and/or email follow-ups by the multidisciplinary care team
    - Nurses
    - Pharmacists
    - Social workers/case managers
    - Frequent follow-up

Motivational Interviewing

- Patient-centered approach
  - More listening than talking
  - Focuses on encouraging patient to find solution
- Components
  - Empathy
    - Attempt to understand the patient's perspective from an external point of view
  - Reflective listening
    - Paraphrase client's comments as statements rather than questions
    - Open-ended questions
      - "Please tell me about…"
  - Encourage self-motivated statements
    - Point out observations and encourage patients to tell you how they are doing
  - Affirm and summarize
  - Recognize, support, and summarize conversation

Other Implications

- More common in chronic rather than acute disease states
- Often due to similar barriers to adherence
- Non-adherence in other chronic health conditions/disease processes
  - HIV
  - Asthma
  - HTN
  - CHF
  - Hyperlipidemia
  - Diabetes
  - Epilepsy

Patient Scenario #1: Pharmacy

85 y/o female with hx of CHF and COPD – ordered oral chemotherapy 2 weeks ago for breast cancer
Arrives at pharmacy with medication bottle, pharmacy bag with patient ed. sheet, and asking to speak to pharmacist about her chemotherapy pills
Notifies pharmacist that she is doesn't know what the medication is for, when to take it, and is scared because one side effect is "potential death"

The pharmacist notices the pill bottle appears full and upon further examination finds that she has not taken any of the pills
What would you do?

Patient Scenario #2: Social Worker

46 y/o male patient and his wife are seen in the outpatient clinic for a routine appt.
The patient tells the oncologist he has not been taking his chemotherapy pills as prescribed because he is afraid of dying and he feels the pills make him sicker, which affects his QOL
The wife states she was unaware that he was not taking his medicine and was unaware that he is scared to die

The oncologist calls the social worker

What would you do?

Patient Scenario #3: Oncology RN

32 y/o female patient admitted to inpatient unit following lab work that showed increased cancer markers after starting her oral chemo regimen
Patient tells the RN that her pills make her nauseous and dizzy and she doesn't take them unless her husband is going to be home to care for the kids
Patient states she didn't think that missing some of the doses would hurt her treatment because "it's not like it's IV medicine"

What would you do?

Patient Scenario #4: Multidisciplinary

An oncologist office notices that a patient who has just started an oral chemotherapy regimen has missed two appointments since starting the treatment
The office finally speaks with him on the phone and he states he cannot afford the medication because he lost his job and his insurance
The patient states he felt embarrassed to tell anyone at the office, so he figured he would not get treated.

What would you do as a team?

Conclusions

- Despite numerous studies showing rates of non-adherence, adherence to oral therapies is an ongoing issue
- Adherence is a priority for ensuring positive therapeutic outcomes, decreased oncology and non-oncology complications, and decreased costs
- Never assume your patient is being adherent to oral therapies
- Observe for predictors and possible barriers
- Communicate and educate
- Addressing adherence is a multidisciplinary process and should involve the healthcare team as a whole
- Adherence is widespread across chronic disease processes and should be addressed at all levels of care

Plant Alkaloids

Classes

- Vinca alkaloids: Periwinkle
- Topoisomerase inhibitors
    - Topoisomerase 1: Asian Happy Tree – Camptotheca Acuminata
    - Topoisomerase 2: Mayapple
- Plant Alkaloids
    - Taxanes: Pacific Yew
    - Epothilones

Most UPMC Hillman Cancer Center chemotherapy decisions are based on:

1. American Cancer Society Guidelines
2. National Comprehensive Cancer Network (NCCN) Guidelines
3. UPMC Hillman Cancer Center Pathways

Vinca Alkaloids: Oncovin (vincristine), Velban (vinblastine), and Navelbine (vinorelbine tartrate)

- Microtubules are dynamic intracellular structures that must breakdown and reassemble for cell division
- Help transport substances across the cell and provide structure
- Bind to microtubular proteins thus arresting mitosis preventing effective functioning of microtubules
    - Prevents cell division and causes apoptosis
- Inhibit angiogenesis, DNA, and protein synthesis

General Information

- Neurotoxic and can cause both sensory and functional disturbances: Paresthesia's, gait instability, cranial nerve disturbance, and peripheral neuropathy
- Constipation
- Myelosuppression
- Sexual/reproductive issues: Impotence, teratogenic
- Vesicant: Warm compresses intermittently for 24 to 48 hours, hyaluronidase protocol
- Alopecia
- Nausea and vomiting: Mild emetogenic potential

The most neurotoxic Vinca Alkaloid drug is:

A. Velban (vinblastine)
B. Oncovin (vincristine)
C. Navelbine (vinorelbine tartrate)

Oncovin (vincristine)

- Dose 0.4-1.4 mg/m2: Usually 2 mg maximum
- Most neurotoxic of class: Stocking/glove, neuropathic pain, autonomic dysfunction, constipation
- Mild myelosuppression
- Dose reduction hepatic dysfunction: Primary excretion through the liver
- Vesicant but administered by IV infusion
    - History of fatal intrathecal administration: Intrathecal administration causes rapid sensory and motor dysfunction, encephalopathy, coma, and death
- Mix in 50cc NSS and infuse IV over 15 minutes

Intrathecal Administration Facts

- Between 1968 and 2011 there were120 cases of mistaken intrathecal administration
    - 44 in US and Canada
- All cases involved dispensing in a syringe
- WHO, Joint Commission, ONS Institute for Safe Medication Practices all support IV infusion rather than IV push
- Extravasation risk: Push 0.03% Drip 0.04%

Clinical Applications

- Lymphoma
    - Cytoxan, Adriamycin, Oncovin, Prednisone (CHOP)
    - Cytoxan, Oncovin, Prednisone (CVP)
    - Cytoxan, Etoposide, Oncovin, Prednisone (CEOP)
    - Etoposide, Prednisone, Oncovin, Cytoxan and Adriamycin (EPOCH)
    - Cytoxan, vincricristine, Adriamycin, and Decadron alternating with methotrexate and cytarabine (HyperCVAD)
    - Very often given with Rituxan
- Ewing's sarcoma
- ALL
- Rhabdosarcoma
- CNS tumors

Tumor Lysis Syndrome (TLS)

- Rapid release of cellular components into the blood after rapid lysis of malignant cells
- Occurs with treatment of cancers with high proliferation rates, large tumor burden or highly sensitive to cytotoxic agents
- Increased potassium, phosphorus, uric acid, low calcium, and renal failure

TLS Prevention

- Hydration
- Allopurinol
- Rasburicase: Enzyme that converts uric acid to inactive, soluble metabolite

TLS Treatment

- Correct electrolytes
- Hydration
- Allopurinol
- Rasburicase
- Hemodialysis if needed

Marqibo (vincristine liposomal)

- Indicated for treatment of adults with Philadelphia chromosome negative ALL for second or beyond relapse or with progression of disease after two or more regimens
- Sensory and motor neuropathy
- Neutropenia, anemia, and thrombocytopenia
- Vesicant
- Intrathecal administration is fatal
- Slower plasma clearance than vincristine
- 2.25 mg/m2 IV infusion over 1 hour every 7 days

Velban (vinblastine)

- Dose: 0.11-6 mg/m2 Q 2-4 weeks and 6 mg/m2 in ABVD regimen
- Nadir: 4-10 days
- Partially metabolized by liver: Dose reduction based on LFTs
- Rare nausea and vomiting

Clinical Applications

- Bladder: Neo-adjuvant, adjuvant, and metastatic uses methotrexate, velban, Adriamycin, cisplatin (MVAC)
- Testicular: Vinblastine, Ifex, and cisplatin (VeIP)
- Hodgkin's: Adriamycin, bleomycin, vinblastine, and dacarbazine (ABVD)
    - Most physicians are now replacing bleomycin with another drug

Navelbine (vinorelbine tartrate)

- Dose: 25 mg/m2 weekly three on and one off
- Nadir 7-10 days
- Dose reduction for liver dysfunction and myelosuppression
- Least neurotoxic of the class
- Semisynthetic vinca alkaloid derived from vinblastine

Clinical Applications

- Breast: Usually single agent or with Herceptin if appropriate
    - Used for metastatic disease after failure of Xeloda, Gemzar, and anthracycline
- No longer part of pathway for lung it has been replaced by targeted agents, immunotherapy, and monoclonal antibodies

Topoisomerase Inhibitors

- Topoisomerase I Inhibitors: Camptothecans
  - Hycamtin (topotecan)
  - CPT-11, Camptosar (irinotecan)
- Topoisomerase II Inhibitors: Podophyllotoxins
  - VP-16, VePesid (etoposide)
- Interfere with the actions of the topoisomerase enzymes I and II that control the changes, breaking and repair, in the DNA structure
- Blocking these enzymes leads to single and double stranded breaks that cannot be repaired
- These breaks lead to cell death by inhibiting DNA synthesis

Clinical Applications: Hycamtin (topotecan)

- Small cell: 1.5 mg/m2 daily X5 days every 21days, second line
  - If poorly tolerated may change to 4mg/m2 weekly
- Ovarian: 4 mg/m2 three weeks on and one week off, fourth line
- Risk for development of myelodysplastic syndromes
- Myelosuppression in all three cell lines significant GI disturbances: Nausea, vomiting, and diarrhea
- Relapsed or refractory ovarian cancer fourth line
- Relapsed small cell lung second line: Oral form 2.3 mg/m2 available 5 days every 21 days
- Sarcomas
- Cervical cancer with cisplatin

Which medication is used to prevent early diarrhea caused by Camptosar (irinotecan)?

A. Atropine
B. Loperamide (Imodium)
C. Octreotide (Sandostatin)

CPT-11, Camptosar (irinotecan)

- Metabolized by Liver
- Dose depends on regimen: 150-200 mg/m2
- Dose limiting side effects: Diarrhea and myelosuppression
- Irritant: Flush with sterile water and apply ice
- Use: Colon, esophageal, and pancreatic cancers

Clinical Applications: CPT-11, Camptosar (irinotecan)

- Colorectal cancer: 5-FU, leucovorin, and irinotecan (FOLFIRI) 180 mg/m2 or irinotecan and Vectibix 180 mg/m2 or Xeloda and irinotecan (XELIRI) 200 mg/mg
- Esophageal: Irinotecan alone for metastatic disease third line and beyond 180 mg/m2
- Pancreatic: 5FU, leucovorin, Irinotecan, and oxaliplatin (FOLFIRINOX) 180 mg/m2

Irinotecan: Early Diarrhea

- Within first 24 hours after administration
- Cholinergic effect: Diarrhea, lacrimation, diaphoresis, piloerection, bradycardia, flushing
- Atropine: 0.25 mg IV can repeat q 15 minutes to 1 mg total for acute diarrhea
- Should be part of the chemotherapy orders

Irinotecan: Late Diarrhea

- Occurs 24 hours or more after administration
- Caused by changes in intestinal mucosa which prevent the absorption of water
- Imodium (loperamide) 4 mg at first episode then 2 mg q2h until no diarrhea for 12 hours
    - 4 mg at bedtime
- Can lead to dehydration, electrolyte imbalance, and renal failure
- May require hospitalization for fluid and electrolyte repletion

Sandostatin (octreotide)

- Stimulates fluid and electrolyte absorption from the GI tract and decreases transit time
  Start with 100-150 mcg q 8 hours
    - May titrate to 500 mcg q8h if needed

Onivyde (liposomal irinotecan)

- Indicated in combination with 5 FU and leucovorin for the treatment of metastatic adenocarcinoma of the pancreas with progression after gemzar based therapy
- Early and late diarrhea
- Cytopenias
- 70mg/m2 every two weeks

Radiation recall causes which of the following:

A. Diarrhea
B. Peripheral Neuropathy
C. Skin irritation

Topoisomerase II Inhibitors: VP-16, VePesid (etoposide)

- Hepatic and renal metabolism and elimination
- Dose: Small cell lung cancer 100 mg/m2 daily for 3 consecutive days every 21 days
- Oral form available but poor bioavailability requires higher dose
- Testicular cancer: Bleomycin, etoposide, and cisplatin (BEP) and etoposide, ifosfamide, and platinum (VIP)
- Stem cell transplant
- Lymphoma: Cytoxan, etoposide, oncovin, and prednisone (CEOP); ifosfamide, carboplatin, etoposide (ICE); Bleomycin, etoposide, doxorubicin, cyclophosphamide, vincristine, procarbazine, and prednisone (BEACOPP)
- Can cause hypotension with rapid infusion
- Anaphylactic reactions
- Nadir: 7-14 days
- Can cause radiation recall
- Risk of secondary malignancy and myelodysplastic syndrome development
- Watch for wheezing, bronchospasm, hypotension and anaphylactic reactions
- Mild GI side effects
- Irritant
- Rare neuropathy
- Rare cardiac complications
- Alopecia

Clinical Applications: VP-16, VePesid (etoposide)

- Small cell lung cancer
- Testicular
- CNS malignancies
- Uterine
- Bladder
- Leukemia
- Lymphoma
- Sarcoma
- BMT
- Cancer of unknown primary

Taxanes: Taxol (paclitaxel), Taxotere (docetaxel), and Abraxane (nab-paclitaxel)

- Inhibit mitosis
- Cell cycle specific
- Pacific Yew
- Hepatic metabolism
- Microtubules must be able to disassemble and reassemble to allow chromosomes to move, align, and separate to make cell replication possible
- Taxanes block the disassembly of microtubules interfering with G2 mitotic phase and inhibiting the replication of cells
- Distortion of mitotic spindles causing chromosome breakage

Which taxane drug is administered by intraperitoneal route for ovarian cancer?

A. Abraxane
B. Jevtana
C. Taxol

Which of the following may be a dose limiting side effect of Paclitaxel (Taxol)?

A. Diarrhea
B. Myalgias
C. Peripheral neuropathy

Taxol (paclitaxel)

- Non-small cell lung cancer (NSCLC)
  - Weekly with radiation 45mg/m2
  - Week on/one off 80mg/m2
  - Every three weeks with carboplatin 200mg/m2
- Ovarian: 175mg/m2 q 3 weeks
  - 135 mg/m2 if given with intraperitoneal therapy
  - Intraperitoneal: 60mg/m2
- Head and neck: Recurrent or metastatic 80mg/m2, weekly
- Metastatic breast: 80mg/m2, 3 weeks on/one off
- Metastatic bladder: 175mg/m2 q 3 weeks
- Angiosarcoma: 80 mg/m2 three weeks on and one off

Paclitaxel Premedication

- Every three weeks: Decadron 20 mg po at 12 and 6 hours prior to therapy
- Weekly: Decadron 20 mg po at 12 and 6 hours prior for week one
- Subsequent weeks Decadron 20mg IV 30 minutes prior to treatment
- Premedicate prior to therapy with Decadron 20 mg IV, anti-emetic, Benadryl, and H2 antagonist
  - Tagamet (cimetidine) 300mg, Pepcid (famotidine) 20 mg or Zantac (ranitidine) 50 mg

Paclitaxel: Administration

- Hypersensitivity: Drug or diluent or both
- Diluent: Cremophor
- Mix in glass or non-PVC container
- Non-PVC tubing, 0.22 micron in-line filter

Paclitaxel: Hypersensitivity Reaction

- Dyspnea
- Hypotension
- Angioedema
- Tachycardia
- Wheezing
- Chest pain

Paclitaxel: Other side effects

- Alopecia
- Cardiovascular events
- Mild nausea, vomiting and stomatitis
- Myalgias and arthralgias
- Neuropathy
- Bone marrow suppression
- Pneumonitis

Clinical Applications

- Non-small cell lung cancer
- Ovarian
- Bladder
- Breast
- Sarcoma
- Head and neck

Taxotere (docetaxel)

- Requires premedication: Decadron 8 mg bid on day before, day of, and day after therapy for every three weeks dosing
- Weekly premeds: Week one Decadron 4 mg po night before and day of therapy
    - Subsequent weeks: Decadron 10 mg IV 30 minutes prior to chemotherapy
- Reduces risk of hypersensitivity reaction and fluid retention
- Use glass or non-PVC containers and tubing
- Risk of hypersensitivity reaction
- Nadir 7 days with risk of neutropenia, 90% incidence of anemia
- Skin reactions, most common on hands and feet, nail changes, conjunctival irritation, hyperlacrimation
- Alopecia
- Neurotoxicity: Paresthesia's and functional deficits
- Mild GI side effects
- Fluid Retention
    - Cumulative toxicity
    - Begins in lower extremities followed by general weight gain
    - Pleural effusions
    - Decreased risk with steroid premedication
    - May require diuretics
    - Usually resolves completely within weeks of last dose

Clinical Applications: Taxotere (docetaxel)

- Breast cancer: After 4 cycles of Adriamycin and Cytoxan, and Herceptin single agent
- Prostate: Metastatic disease with prednisone
- Non-small cell lung cancer: Metastatic disease used single agent with cisplatin or ramucirumab
- Head and neck, uterine leiomyosarcoma, and gastric
    - Dose: 75-100 mg/m2

Abraxane (nab-paclitaxel)

- Bound to albumin
- Does not require the same premedication or administration precautions as Taxol
- Breast: Single agent 260mg/m2 or in combination with Avastin 100mg/m2 third line and beyond
- Pancreatic: In combination with gemcitabine 125mg/m2
- NSCLC: In combination with carboplatin three weeks on and one week off
- Can use with patients who have hypersensitivity to taxanes
- Less neutropenia than taxanes
- Peripheral neuropathy

Jevtana (cabazitaxel)

- Approved as second line therapy for patients with hormone refractory metastatic prostate cancer following treatment with Taxotere
    - Third line in pathways
- Combined with Prednisone 10 mg/day
- Microtubule inhibitor
- Derived by semi-synthesis with molecules extracted from yew needles
- Premedication: Antihistamine-Benadryl 25 mg IV, steroid-Decadron 8 mg IV, H2 blocker-Pepcid 20 mg IV, and an antiemetic-Kytril 1 mg IV
- 20 mg/m2 over one hour every 3 weeks
- In line 0.22-micron filter
- Do not use PVC infusion bags or tubing

Epithilones: Ixempra (ixabepilone)

- Like taxanes inhibit the function of microtubules
- Significant difference in structure from taxanes, less susceptible to taxane drug resistance
- Two phase three clinical trials comparing Ixempra plus capecitabine to capecitabine alone showed improved overall response 42% vs. 29%
- Used in combination with capecitabine for taxane and anthracycline resistant, recurrent or metastatic breast cancer
- Monotherapy for patients who do not tolerate capecitabine or are not candidates for combination therapy
- Third line and beyond
- Neuropathy
- Hematologic toxicity
- May cause myalgias and arthralgias
- Hypersensitivity reaction: Premedication with H1 antagonist-Benadryl and H2 antagonist-Zantac
- No oral steroid premedication

Dose and Administration: Ixempra (ixabepilone)

- PVC free bags and tubing and a 0.22-micron filter

Clinical Application: Ixempra (ixabepilone)

- Breast 40mg/m2 every three weeks

Principles of Cancer: Drug Therapy

Review of Current Cancer Statistics

Estimated New Cancer Cases in US 2020

Males		Female	
Prostate	21%	Breast	30%
Lung and bronchus	13%	Lung and bronchus	12%
Colon and rectum	9%	Colon and rectum	8%
Urinary bladder	4%	Uterine corpus	7%
Melanoma of the skin	7%	Melanoma of the skin	4%
Kidney and renal pelvis	5%	Thyroid	4%
Non-Hodgkin's lymphoma	5%	Non-Hodgkin's lymphoma	4%
Oral cavity and pharynx	4%	Kidney and renal pelvis	3%
Leukemia	4%	Pancreas	3%
Pancreas	3%	Leukemia	3%

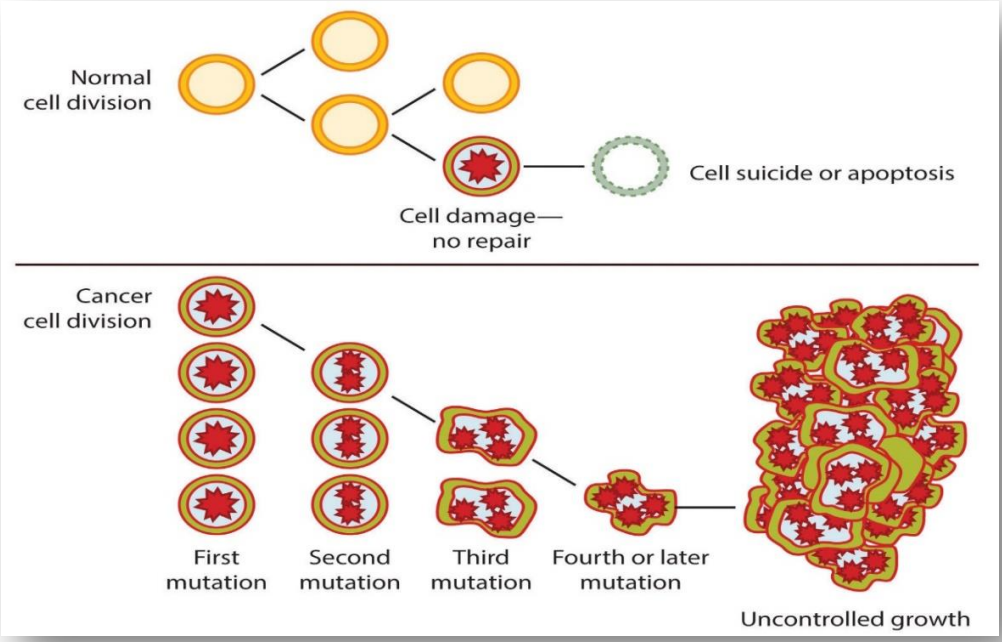
Estimated Cancer Deaths in US 2020

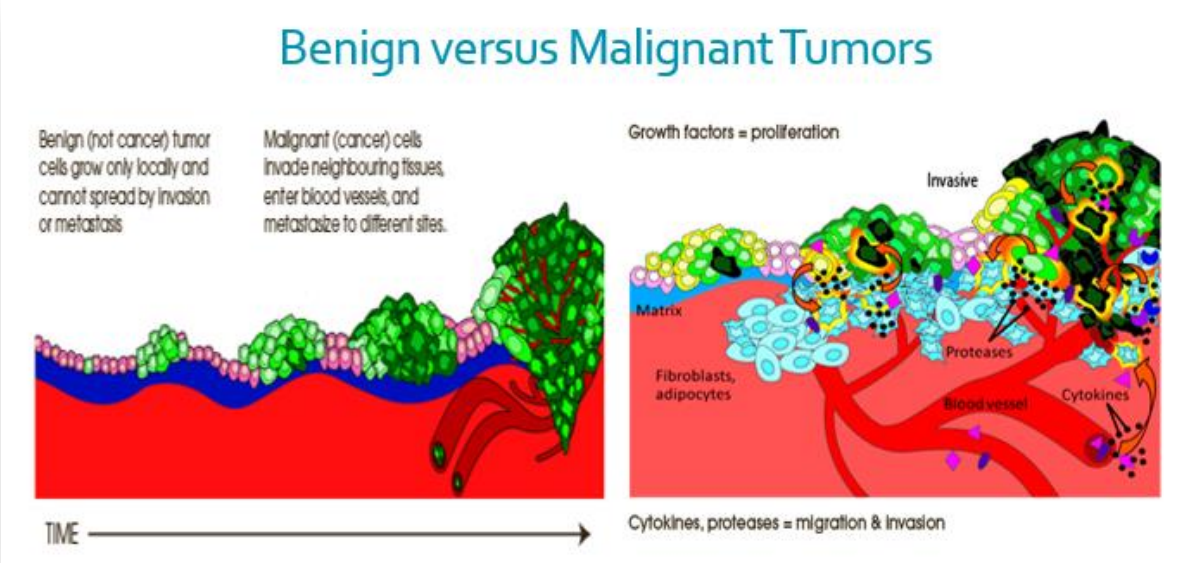
Male: 323,630		Female: 286,010	
Lung and bronchus	23%	Lung and bronchus	22%
Prostate	10%	Breast	15%
Colon and rectum	9%	Colon and rectum	9%
Pancreas	8%	Pancreas	8%
Liver and intrahepatic bile duct	7%	Ovary	5%
Leukemia	4%	Uterine corpus	4%
Esophagus	4%	Liver and intrahepatic bile duct	4%
Urinary bladder	4%	Leukemia	4%
Non-Hodgkin's lymphoma	4%	Non-Hodgkin's lymphoma	3%
Kidney and renal pelvis	3%	Brain and other nervous system	3%
Brain and other nervous system	3%		

Characteristics of Tumors

- What Is cancer?
  - A group of more than 200 diseases caused by genetic alterations and defective cell function
  - Characterized by unregulated growth that
  - Capable of spreading to other parts of the body

Formation of a Tumor





Characteristics of Benign Tumors

- Slow continuous or inappropriate growth
- Retained morphology of parent cell
- Differentiated cells may maintain function
- Often encapsulated with fibrous tissue

Characteristics of Malignant Tumors

- Abnormal morphology
- Poorly differentiated
- No contact inhibition
- Unregulated growth pattern
- No programmed apoptosis
- Loss of specific function
- Migration to other areas of the body

Common Cancer Classifications

- Carcinoma: Begins in the skin or in tissues that line or cover internal organs: Adenocarcinoma, basal cell carcinoma, squamous cell carcinoma, transitional cell carcinoma
- Sarcoma: Begins in bone, cartilage, fat, muscle, blood vessels, or other connective or supportive tissue
- Leukemia: Begins in blood-forming tissue, bone marrow, and produces large numbers of abnormal blood cells to be released in the blood
- Lymphoma: Begins in the cells of the immune system: Lymphatic system
- Myeloma: Begins in the cells of the immune system specifically the antibody-secreting immune cell plasma cell
- Blastoma: Derived from immature "precursor" cells or embryonic tissue,
- Central nervous system cancers: Begins in the tissues of the brain and spinal cord
- Germ Cell Cancers: Derived from pluripotent cells, i.e., testicle or ovary

Cancer “Prefixes”

- Adeno – gland
- Chrondo – cartilage
- Erythro – red blood cell
- Hemangio – blood vessels
- Hepato – liver
- Lipo – fat
- Lympho – lymphocyte
- Melano – pigment cell
- Myelo – bone marrow
- Myo – muscle
- Osteo – bone

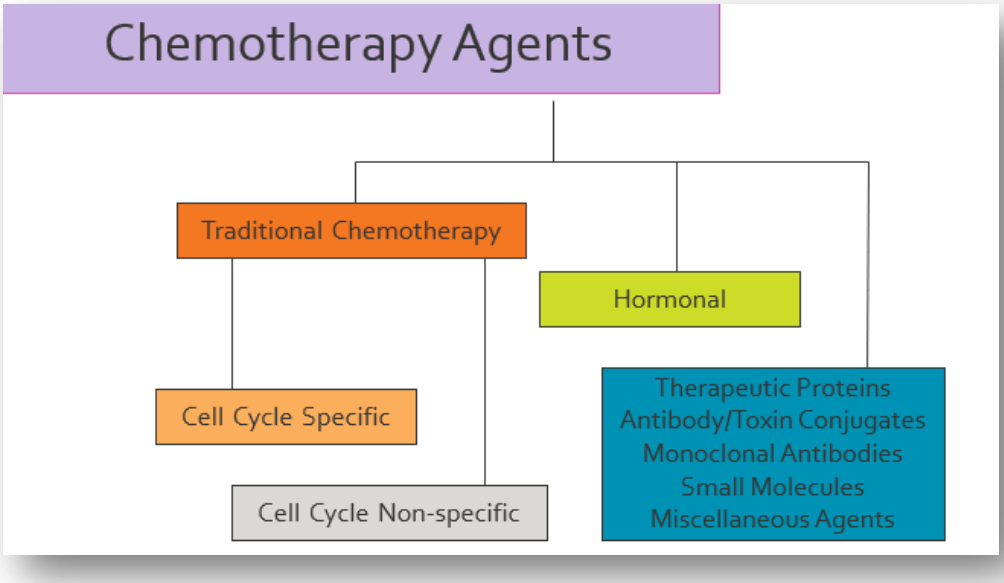
What is Chemotherapy’s Contribution to Treating Cancer

- Chemotherapy can
    - Decrease tumor volume
    - Alleviate symptoms
    - Prolong life in some metastatic cancers
    - Cure of disease
- Single-agent chemotherapy: Monotherapy
- Multiple-agent chemotherapy: Combination chemotherapy

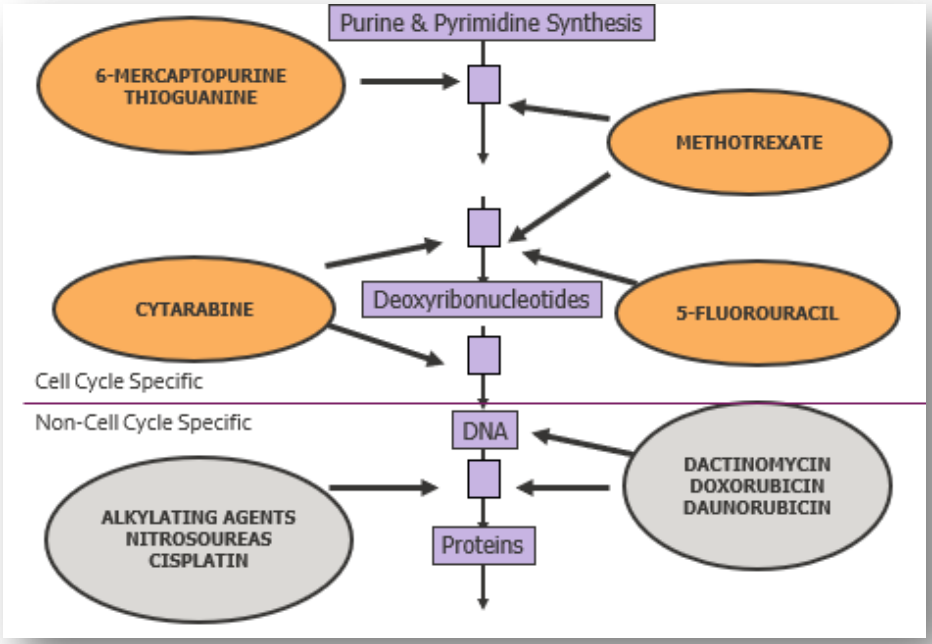
Chemotherapy Classification

- Cytotoxic: Kills the cells
  - Traditional anticancer agents
    - Cell-cycle specific agents
    - Cell-cycle non-specific agents
- Cytostatic: Suppresses growth of cells
  - Newer anticancer agents
    - Small molecules
    - Antibody directed agents
    - Targeted therapies
    - Signal transduction inhibitors
- Systemic chemotherapy
  - Cytotoxic drugs are used to destroy cancer cells or prevent cellular replication by interfering with DNA and RNA, and vital cellular proteins
    - Classified according to the pharmacologic action of effect on the cellular reproduction cycle
    - Goals
      - Cure
      - Control
      - Palliation
      - Reduction of cells
      -

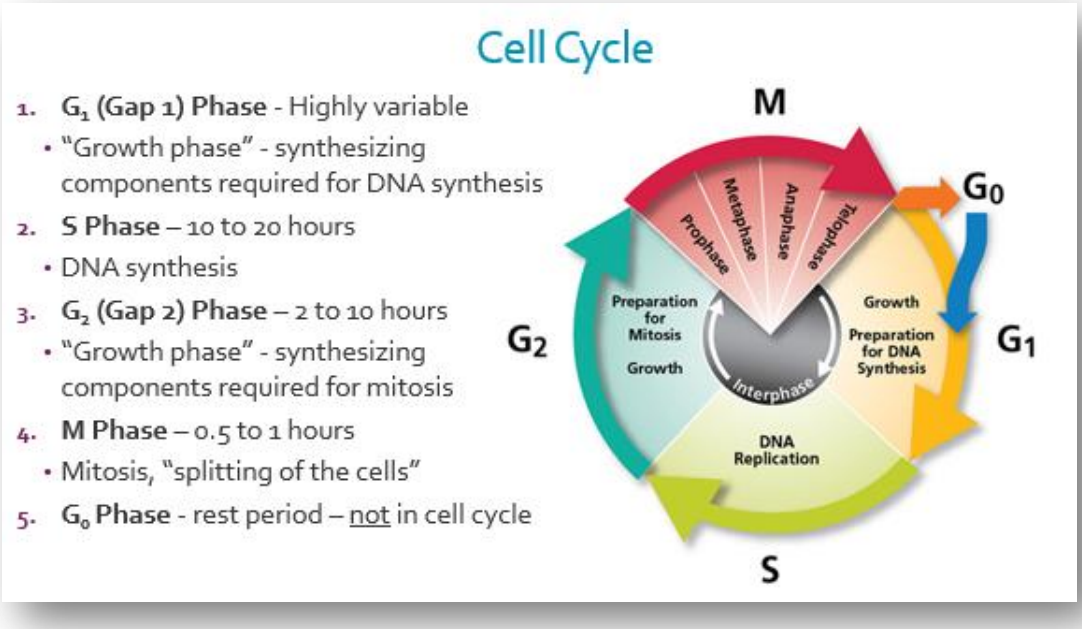
Recognize the Importance of the Cell Cycle and Identify its Relationship to the Efficacy of Chemotherapy



Cell Cycle Specific Treatments vs Non-cell Cycle Specific Treatments



Cell Cycle Phases



Cell Proliferation Rates

None	• Muscle • Bone • Cartilage • Nerve
Slow	• Lung • Endocrine glands • Vascular endothelium • Liver • Kidney
Rapid	• Hair follicle • Bone marrow • Gastrointestinal mucosa • Ovary/Testies

Chemotherapy Agents

Cell Cycle Specific Chemotherapeutic Agents	Non-Cell Cycle Specific Agents

• G_1 Phase dependent agents
  ○ Elspar (asparaginase)
  ▪ Oncaspar (pegasparaginase)
  ○ Erwinaze (asparaginase erwinia chrysanthemi)
  ○ Apsarlas (calasparaginase pegol-mknl)
  ○ Corticosteroids: Prednisone
• S Phase dependent agents
  ○ Purine Antagonists
  ○ Pyrimidine Antagonists
  ○ Folate Antagonists
  ○ Camptothecins
• G2 Phase dependent agents
  ○ Bleomycin
  ○ Podophyllotoxins
  ▪ Etoposide
  ▪ Teniposide
• M Phase specific agents
  ○ Vinca Alkaloids
  ▪ Vincristine
  ▪ Vinblastine
  ▪ Vinorelbine
  ▪ Liposomal Vincristine
	• Alkylating agents
	  ○ Chlorambucil
	  ○ Ifosfamide
	  ○ Cyclophosphamide
	  ○ Melphalan
	  ○ Busulfan
	  ○ Carmustine
	  ○ Lomustine
	• Non-classic alkylating agents
	  ○ Procarbazine
	  ○ Dacarbazine
	  ○ Temozolomide
	  ○ Bendamustine
	  ○ Ixabepilone
	• Anthracycline antibiotics
	  ○ Doxorubicin
	  ○ Liposomal doxorubicin
	  ○ Idarubicin
	  ○ Epirubicin
	  ○ Mitoxantrone
	• Other antitumor antibiotics
	  ○ Dactinomycin
	• Platinum agents
	  ○ Cisplatin
	  ○ Carboplatin
	  ○ Oxaliplatin

- Taxanes
    - Docetaxel
    - Paclitaxel
    - Nab-abraxane
    - Cabazitaxel
- Non-Taxane Agents
    - Eribulin Mesylate

Why is Combination Therapy Superior?

- Tumor cells are frequently resistant or become resistant to a single agent
    - By using multiple agents, the chance of resistance decreases
- Each drug is used at its most efficacious dose (i.e., full dose)
- Each drug works with a different mechanism of action
- Each drug should have a different toxicity pattern

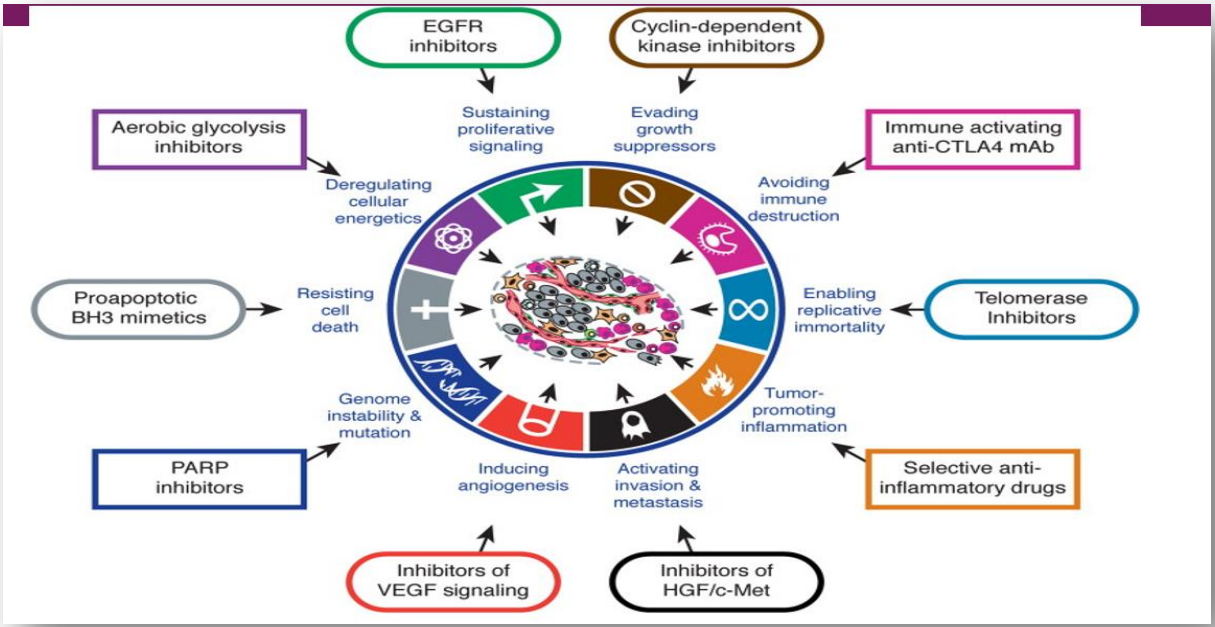
Common Chemotherapy Regimens

- Acute lymphocytic leukemia (ALL)
    - Vincristine, prednisone, doxorubicin, L-asparaginase
- Hodgkin's lymphoma
    - Adriamycin, bleomycin, vinblastine, dacarbazine (ABVD)
- Diffuse large cell (Non-Hodgkin) lymphoma
    - Cyclophosphamide, doxorubicin, vincristine, and prednisone (CHOP)
        - 5 to 8 drug regimens
- Testicular carcinoma
    - Bleomycin, cisplatin, and vinblastine or etoposide
- Colorectal carcinoma
    - 5-fluorouracil, leucovorin, oxaliplatin/irinotecan (FOLFOX/FOLFIRI)

Compare and Contrast Traditional Chemotherapy Agents and Targeted Therapies

- Targeted anticancer agents: The genetic link
    - All cancers are caused by genetic alterations at the cellular level.
        - Germline alterations: Inherited during meiosis or during changes in ova/sperm DNA present before birth
        - Acquired and spontaneous alterations: Accumulate within DNA throughout life due to environmental agent exposure responsible for sporadic cancers
    - Certain genetic alterations can be identified and targeted for treatment

Hallmarks of Cancer: The Next Generation



Types of Targeted Therapies

- Monoclonal antibodies
  - Including immune checkpoint inhibitors
- Small molecules: Tyrosine kinase inhibitors (TKI)
  - Therapeutic proteins
  - Alpha-IFN for HCL, CML, others
  - IL-2 (1992) for melanoma, renal cell
  - Peginterferon-alpha-2b for melanoma
- Antibody/toxin conjugates
  - Ontak (IL-2/ricin) for CTCL
  - Mylotarg (CD-33/calicheamycin) for AML
- Recombinant vaccines: No live virus
  - Gardasil for prevention of cervical cancer, precancerous genital lesions and genital warts
  - Cervarix
- Autologous cellular immunotherapy
  - Provenge (sipuleucel-T): Personalized immunotherapy for advanced prostate cancer
  - Recombinant fusion proteins
  - Zaltrap (ziv-aflibercept) Colorectal cancer
- Chimeric Antigen Receptor T-Cell Therapy (CAR-T)
  - Kymriah (tisagenlecleucel): ALL

Monoclonal Antibodies

- Laboratory-produced molecule carefully engineered to attach to specific defects in cancer cells
- Make the cancer cell more visible to the immune system
    - Block growth signals
    - Stop new blood vessels from forming

Immune Checkpoint Inhibitors

- T-cells have built-in checkpoints which prevent them from attacking normal cells
    - PD-1/PDL-1 complex
    - CTLA-4/B7-1/B7-2 complex
- Some tumor cells utilize these surface protein complexes to avoid immune-mediated cell death
- Checkpoint inhibitors attach to surface proteins on tumor cells or T cells and prevent formation of checkpoint complexes

Immune Checkpoint Inhibitors

- PD-1 inhibotors
    - Keytruda (pembrolizumab)
    - Opdivo (nivolumab)
    - Libtayo (cemiplimab-rwic)

- PDL-1 inhibitors
    - Tecentriq (atezolizumab)
    - Bevencio (avelumab)
    - Imfinz (durvalumab)
- CTLA-4
    - Yervoy (ipilimumab)

Incorporating Targeted Agents into Traditional Chemotherapy Regimens

- Metastatic colorectal cancer
    - Bevacizumab: First, second and third line
        - 5mg/kg dose with folinic acid, fluorouracil and oxaliplatin (FOLFOX), folinic acid, fluorouracil, and irinotecan (FOLFIRI) or capecitabine, qxaliplatin (CapeOx)
    - Cetuximab: KRAS wild-type only
        - Second line as single agent or with irrinotecan
    - Panitumumab: KRAS wild-type only
- Advanced lung cancer, nonsmall cell lung cancer (NSCLC)
    - Bevacizumab
        - Up to 15mg/kg dose with carboplatin and paclitaxel
    - Cetuximab plus traditional chemotherapy regimen
    - Erlotinib or gefitnib only: EGFR mutation

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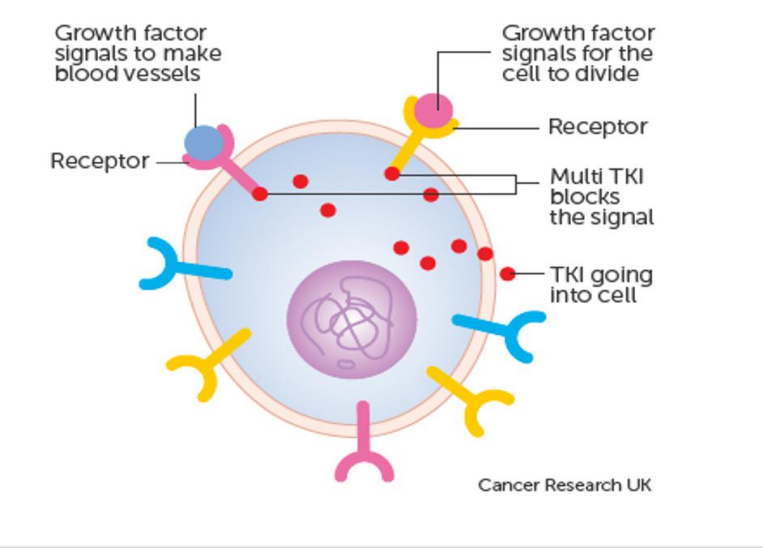
Small Molecules/TKIs



Challenges of Newer Therapies

- Who should be treated?
  - Quantity and/or presence of receptor sites don't necessarily correlate with response, wild type vs. mutations, or early-stage vs. late-stage disease
- How do you verify activity/response?
  - Testing of biomarkers and determination of stable disease vs. complete response to therapy
- What is the optimal dose
  - Less frequent dose limiting toxicities, what is minimum effective dose?
- How do you manage side effects
  - Skin rashes, diarrhea, hypertension, electrolyte abnormalities, thyroid abnormalities, fluid retention, proteinuria, hepatotoxicity, interstitial lung disease, pancreatitis, visual disturbances, wound healing, bleeding risk, cardiac toxicity, etc.
- Multiple drug-drug interactions
  - Multiple hepatic enzymes involved, increased bleeding risk present, and QT prolongation are possible
- What is a proper dose adjustment: Considerations
  - Should we dose adjust
  - How much of an adjustment is too much…10%, 25%, 50%?
  - Can you split the dosage form, or should you practice this?
- What agents should be used together?
  - Single agent
    - Typically displays little response unless blocks multiple targets
    - Is combination therapy needed to inhibit full signaling cascade?

Hormonal Therapies Classes: Breast

- Selective estrogen receptor modulators (SERMs)
  - Nolvadex (tamoxifen)
- Selective estrogen receptor down regulators (SERDs)
  - Faslodex (fulvestrant)
- Aromatase inhibitors (AIs)
  - Arimidex (anastrozole)
  - Aromasin (exemestane)
  - Femara (letrozole)

Hormonal Therapies Classes: Prostate

- Luteinizing hormone-releasing hormone (LHRH) agonists
  - Lupron (leuprolide)
  - Zoladex (goserelin)
  - Trelstar (triptorelin)
- LHRH antagonists
  - Firmagon (degarelix)
- Anti-Androgens
  - Eulexin (flutamide)
  - Casodex (bicalutamide)
  - Nilandron (Nilutamide)
  - Erleada (apalutamide)
  - Nubeqa (darolutamide)

Rationale Design and Utilization of Chemotherapy for Cancer Treatment

- Pathological confirmation of disease
  - A cancer diagnosis is made by determining the anatomical origin of the tumor
    - The primary site is where the cancer first developed
    - The secondary site is where the cancer metastasized
  - A diagnosis is confirmed with advanced imaging and biopsy
    - Imagining can pinpoint location and metastases
    - Biopsies can provide more specific information about the tumor to help determine the best treatment
- Local vs. disseminated disease
  - Localized tumors
    - Surgery and radiation are generally much more effective
    - Chemotherapy has a limited role
  - Disseminated or systemic cancer
    - Chemotherapy becomes the main treatment option
    - Hematological malignancies
      - Widespread at diagnosis, so chemotherapy given with intent to cure
    - Metastatic disease
      - Very rarely curative where intent is to prolong life or for palliating symptoms

- Treatment intent
    - Palliative
        - Goal is to increase quality of life, not create a cure, while providing cancer treatment
        - Provide support for symptoms related to cancer and side effects of treatment as early as possible
        - Social, psychological, and spiritual support
    - Curative
        - Goal is cure disease

Selection of Effective Anticancer Agents

- Is the agent or regimen appropriate for the type of cancer?
    - Regimens are developed based on clinical trials and research
    - There are typically "standard" regimens based on the type of cancer and other factors such as:
        - Cancer stage
        - Patient's age and overall health
        - Comorbidities
        - Previous treatments
    - If there is no standard treatment or the patient has progressed on the standard, investigation drugs and/or regimens are considered
    - Absorption, distribution, metabolism, and excretion (ADME)
    - Resistance concerns
        - Dose intensification
        - Combination chemotherapy regimens help to prevent development of resistance by interrupting multiple processes in the cell cycle
        - Strategy for overcoming chemotherapy resistance
            - "Standard" doses of effective combination chemotherapy are developed from clinical trials and are sufficient for patients with sensitive tumors
            - High doses are necessary for the subset of patients with tumors that have relative drug resistance
            - Planned doses or schedules of chemotherapy should not be modified in anticipation of toxicity that has not happened or for short-term, non-life-threatening toxicity, e.g., emesis or mild neutropenia
    - Patient performance status
        - Scales are used to measure how cancer affects a patient's daily living abilities

- Quality of life
  - There are many resources available to patients to help maintain or improve quality of life during and after treatment which include
    - Nutrition
    - Physical exercise
    - Emotional and spiritual support
    - Networking with other cancer patients and survivors
    - Help with appearance
  - Maintaining quality of life helps patients tolerate and complete therapy, which improves treatment outcomes

Supportive Care Drugs

- NSAIDS
- Steroids
- Antiemetics
- Analgesics
- Sedatives
- Antidepressants
- Antibiotics
- Anti-virals
- Antifungals
- Growth factors

Review NCI Common Toxicity Criteria Adverse Events (NCI CTCAE) Classifications

- Classifying and grading toxicity
  - Toxicity is classified into general area: Bone marrow, cardiac muscle, GI system, etc.
  - For toxicity caused by various cancer treatments, the NCI CTCAE version 5.0 is commonly used to describe toxicity

NCI CTCAE version 5.0 Grading

Grade	Severity
Grade 1	Mild AE
Grade 2	Moderate AE
Grade 3	Severe AE
Grade 4	Life threatening or disabling AE
Grade 5 (if appropriate)	Death-related to AE

Recognize the Financial Impact of Cancer Treatment

- Cost of cancer care
  - The economic impact of cancer in the United States is staggering
    - $80.2 billion spent on cancer care in 2015
    - Cancers resulting in greatest expenditures include lymphoma, breast, colorectal, lung, and prostate
    - Lost productivity estimated at $135 billion
    - In 2020, it is projected at least $158 billion will be spent on cancer care
  - Estimates do not include out of pocket expenses
    - Increasing expenditures on targeted and oral chemotherapy agents
    - Number of cancer survivors and cost of cancer care expected to rise

Out of Pocket Expenses

- Copayments
- Cancer/supportive care treatments
- Medical supplies
- Transportation
- Housekeeping
- CAM therapies
- Financial planning
- Child/adult daycare
- Drug costs
- Lodging
- Food
- Nutritional supplements
- Clothing
- Legal

Professional Oncology Organizations

- American Society of Clinical Oncology (ASCO)
- Association of Cancer Online Resources (ACOR)
- American Society of Hematology (ASH)
- National Cancer Institute (NCI)
- National Comprehensive Cancer Network (NCCN)
- Multinational Association of Supportive Care in Cancer (MASCC)
- American Cancer Society (ACS)
- World Health Organization (WHO)
- Hematology/Oncology Pharmacy Association (HOPA)
- Oncology Nursing Society (ONS)

Tyrosine Kinase Inhibitors: Part 1

Tyrosine Kinase Inhibitors (TKIs)

- Enzymes that catalyze the transfer of phosphate from ATP to tyrosine residues in polypeptides
    - Regulate cellular proliferation, survival, differentiation, function, and motility

Common Features of TKIs

- Bind to the ATP site of the targeted tyrosine kinase
    - Inhibit more than one tyrosine kinase
- Oral agents
    - Half-lives allow either daily or twice daily dosing
    - May require dose adjustments for toxicities
- Nearly all are CYP3A4 substrates; consider drug-drug interactions with strong inducers and inhibitors of CYP3A4
    - Strong inducers: Phenytoin, rifampin, carbamazepine
        - Strong inhibitors: Voriconazole, clarithromycin
        - Pregnancy category D

Gleevec (imatinib)

Indications

- Newly diagnosed Philadelphia chromosome positive chronic myeloid leukemia
- Ph+ CML in chronic phase
- Ph+ CML in blast crisis (BC), accelerated phase (AP), or in chronic phase (CP) after failure of interferon-alpha therapy
- Relapsed or refractory Philadelphia chromosome positive acute lymphoblastic leukemia (PhALL)
- Kit (CD117) positive unresectable and/or metastatic malignant gastrointestinal stromal tumors (GIST)
- Adjuvant treatment following resection of Kit (CD117) positive GIST

Indication	Dose
CML: Chronic phase	400 mg PO daily (can ↑ to 600 mg or 800 mg daily)
CML: Accelerated phase or blast crisis	600 mg PO daily (can ↑to 800 mg daily)
GIST	400 mg PO daily
Ph+ALL	600 mg PO daily

- Administer dose with meal
- Doses of 400 mg or 60 mg should be given once a day
- Doses of 800 mg should be given as 400 mg twice a day
- Available as 100 mg and 400 mg scored tablets

Drug Adjustments

- Mild renal impairment (creatinine clearance (CrCl) 40-59ml/min): Doses > 600mg not recommended
- Moderate renal impairment (CrCl 20-39ml/min): Decrease dose 50%
- Severe hepatic impairment: Decrease dose 25%
- Dose adjustments for neutropenia and thrombocytopenia

Drug Interactions

- Metabolized by CYP3A4 and CYP2D6
- Recommended to use low molecular weight heparin or unfractionated heparin instead of warfarin
- May need to increase dose with phenytoin

Mechanism of Action

- Inhibits BCR-ABL tyrosine kinase: Abnormal tyrosine kinase created by the Philadelphia chromosome
- Inhibits platelet derived growth factor receptor (PDGFR-α), stem cell factor (SCF) and c-kit receptor tyrosine kinases
- Targets the ATP binding site of these receptors
- Binds to and fixes the enzyme in its inactive conformation

Side Effects and Management

- Myelosuppression
    - Monitor CBC weekly for first month, biweekly for second month, and then periodically
    - Consider dose reduction, interruptions, and discontinuation
- Diarrhea
    - Loperamide and fluid replacement
- Edema and fluid retention
    - Monitor weight regularly and baseline left ventricle ejection fraction (LVEF)
    - Diuretics and support care
    - Hold if weight gain
- Muscle cramps
    - Over the counter (OTC) pain reliever
    - Prescription pain medication
    - Calcium and Magnesium replacement
- Rash
    - Topical or systemic steroids
    - Oral antihistamines
    - Dose interruption or discontinuation
- Hepatotoxicity
    - Monitor liver function tests (LFT) at baseline and monthly or as clinically indicated

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Sprycel (dasatinib)

Indications
- Newly diagnosed Ph+ CML in chronic phase
- Any phase Ph+ CML with resistance or intolerance to prior therapy including imatinib
- Ph+ ALL with resistance or intolerance to prior therapy

Indication and Dosing
- Chronic Phase Ph+CML: 100 mg PO once daily
- Accelerated or Blast Phase CML: 100 mg PO once daily
- Ph+CML, Ph+ ALL: 140 mg PO once a day

Administration
- Administer orally with or without a meal in the morning or evening
- Available as 20 mg, 50 mg, 70, mg, 80 mg, 100 mg, and 140 mg tablets
- Do not crush or cut tablets

Drug Interactions
- H2 antagonists and proton pump inhibitors (PPIs)
    - May decrease levels of dasatinib
    - Consider antacids instead (separate doses by at least 2 hours)
- CYP3A4 inducers: Consider increasing dasatinib dose
- CYP3A4 inhibitors: Consider decreasing dasatinib dose

Mechanism of Action
- Inhibits BCR-ABL tyrosine kinase
- Binds both the active and inactive conformations of the BCR-ABL tyrosine kinase
- Inhibits c-kit, EPHA2, PDGFR-β, and SRC family of tyrosine kinases

Side Effects and Management
- Myelosuppression
    - Monitor CBC weekly for first two months and then periodically
    - Consider dose reduction, interruption or discontinuation
- Bleeding complications
    - Use with caution if patient is on anticoagulation medications
    - Monitor CBC
- Fluid retention
    - Supportive care including diuretics or short courses of steroids
- QTc prolongation
    - Correct hypokalemia and hypomagnesemia prior to use
    - Use with caution in patients taking anti-arrhythmic medications or other medications that prolong QTc interval

- Cardiac dysfunction or Pulmonary arterial hypertension (PAH)
    - Monitor patients for signs and symptoms of cardiac dysfunction and treat appropriately
    - Monitor for dyspnea, fatigue, hypoxia and fluid retention
    - Discontinue if PAH is confirmed

Tasigna (nilotinib)

Indications and Dosing
- Newly diagnosed Ph+ CML in chronic phase: 300 mg PO BID
- Chronic or accelerated phase Ph+ CML with resistance or intolerance to prior therapy that included imatinib: 400 mg PO BID
    - Eligible newly diagnosed Ph+ CML-CP patients and Ph+ CML-CP patients resistant or intolerant to imatinib who have received nilotinib for a minimum of 3 years and achieved a sustained molecular response (MR4.5) may be considered for treatment discontinuation

Administration
- Take doses approximately 12 hours apart
- Swallow capsules whole with water
- Do not eat for 2 hours before dose or for 1 hour after dose
- Available as 50 mg, 150 mg and 200 mg capsules

Adverse Events
- Box Warning: QTc Prolongation and Sudden Deaths
- Prolongs the QTc interval
- Should not be used in patients with hypokalemia, hypomagnesemia, or long QT syndrome
    - Monitor for hypokalemia and hypomagnesemia and correct deficiencies
- EKGs should be obtained to monitor the QTc at baseline, seven days after initiation, and periodically thereafter, as well as following any dose adjustments
- Avoid concomitant use of drugs known to prolong the QTc interval and CYP3A4 inhibitors
- Avoid food 2 hours before and 1 hour after taking the dose

Drug Interactions
- Avoid use of PPIs
    - If H2 blockers or antacids necessarily make sure to separate doses by several hours
- Avoid administration with agents that prolong QTc interval

Mechanism of Action
- Inhibits BCR-ABL tyrosine kinase
- Similar to imatinib binds to the inactive BCR-ABL tyrosine kinase
- Inhibits c-kit and PDGFR-β tyrosine kinases

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Side Effect and Management

- Myelosuppression
  - Monitor CBC every two weeks for the first two month, then monthly
  - Consider dose reduction, interruption or discontinuation
- Elevated serum lipase
  - Monitor lipase periodically
  - Interrupt dose consider pancreatitis if accompanied by abdominal symptoms
- Elevated liver function tests (LFTs)
  - Monitor bilirubin AST/ALT and alkaline phosphatase periodically
- Cardiac and arterial vascular occlusive events
  - Monitor and manage cardiovascular risk factors
- Electrolyte abnormalities
  - Monitor for hypophosphatemia, hypokalemia, hyperkalemia, hypocalcemia, and hyponatremia
    - Correct abnormalities prior to starting therapy
    - Monitor electrolytes during therapy

Bosulif (bosutinib)

Indications and Dosing

- Newly diagnosed chronic phase Ph+CML: 400 mg PO
- Chronic, accelerated or blast phase: 500 mg PO daily
- Ph+ CML with resistance or intolerance to prior therapy: 500 mg PO daily
- Consider increasing by 100 mg up to 600 mg PO daily if response not achieved or maintained in the absence of grade 3 or greater adverse effects

Drug Interactions

- Avoid with concomitant strong and moderate CYP3A4 inhibitors or strong CYP3A4 inducers
- Consider short acting antacids or H2 blockers and separate by more than 2 hours instead of proton pump inhibitors

Administration

- Administer with food; swallow whole do not chew or crush
- Available as 100 mg, 400 mg and 500 mg tablets

Mechanism of Action

- Inhibits the BCR/ABL tyrosine kinase
  - Bosutinib inhibited 16 of 18 imatinib resistant forms of BCR/ABL in murine models
- Inhibits the SRC family of tyrosine kinases

Side Effects and Management

- Diarrhea, nausea, vomiting, abdominal pain
    - Standard of care anti-emetics, antidiarrheals, and fluid replacement
    - Dose Adjustments maybe requires
- Myelosuppression
    - Monitor CBC weekly for first month, then monthly as clinically indicated
    - Dose adjustments may be required
- Fluid retention: Pleural effusions, pericardial effusion, peripheral edema, and pulmonary edema
    - Manage per standard of care
    - Interrupt, dose reduce or discontinue as indicated
- Renal toxicity
    - Monitor renal functions at baseline and periodically while on treatment

Adverse Reactions: Approximately 20%

- Diarrhea, nausea, thrombocytopenia, vomiting, abdominal pain, rash, anemia, pyrexia, and fatigue

Iclusig (ponatinib)

Indications and Dosing

- Adults with T315I-postive CML (chronic, accelerated or blast phase) or T315I-positve Ph+ ALL
- Adults with chronic, accelerated or blast phase CML or Ph+ ALL for whom no other TKI therapy is indicated
- Optimal dose has not been identified**,** recommend starting at 45 mg PO once daily
- Risk Evaluation and Mitigation Strategy (REMS) program

Administration

- Administer with or without food
- Available as 15 mg and 45 mg tablets

Box Warnings

- Arterial Occlusion**:** Arterial occlusion has occurred in at least 35% of ponatinib-treated patients including fatal myocardial infarction, stroke, stenosis of large arterial vessels of the brain, severe peripheral vascular disease, and the need for urgent revascularization procedures
    - Some patients experienced more than 1 type of event
    - Patients with and without cardiovascular risk factors, including patients less than 50 years old, experienced these events
    - Monitor for evidence of arterial occlusion
    - Interrupt or stop ponatinib immediately for arterial occlusion
    - A benefit-risk consideration should guide a decision to restart ponatinib

- Venous thromboembolism**:** VTE has occurred in 6% of ponatinib-treated patients monitor for evidence of thromboembolism
    - Consider dose modification or discontinuation in patients who develop serious VTE.
- Heart Failure: Heart failure, including fatalities, occurred in 9% of ponatinib-treated patients
    - Monitor cardiac function. Interrupt or stop ponatinib for new or worsening heart failure.
- Hepatotoxicity: Hepatotoxicity, liver failure and death have occurred in ponatinib-treated patients
    - Monitor hepatic function
    - Interrupt ponatinib if hepatotoxicity is suspected.

Drug Interactions

- Reduce dose with concurrent strong CYP3A4 inhibitors
- Not studied with CYP3A4 inducers; avoid
- Avoid administration with PPIs and H2 blockers

Mechanism of Action

- Inhibits BCR-ABL including T315I; also inhibits VEGFR, PDGFR, SRC, KIT, FLT3 and other tyrosine kinases

Side Effects and Management

- Hypertension
    - Monitor for high blood pressure and treat as clinically indicated
- Pancreatitis
    - Monitor lipase every two weeks for the first two months and then monthly
    - Interrupt or discontinue drug if needed
- Neuropathy
    - Monitor for signs of neuropathy such as paresthesia or weakness
- Hemorrhage
    - Interrupt for serious or severe hemorrhage
        - Hemorrhage most commonly occurs in patients with thrombocytopenia
- Fluid retention
    - Monitor for fluid retention: Peripheral edema, pleural edema, or pericardial effusions
    - Interrupt, reduce, or discontinue drug if needed
- Cardiac arrythmias
    - Educate patients of symptoms of bradycardia
        - Fainting
        - Dizziness
        - Chest pain
    - Educate patients of symptoms of tachycardia
        - Palpitations
        - Dizziness

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- Myelosuppression
    - Monitor CBC every two weeks for three months and then monthly as indicated
    - Interrupt treatment for absolute neutrophil count (ANC) < 1000/mm2 or platelets < 50, 000/mm2
- Tumor lysis syndrome (TLS)
    - Ensure adequate hydration
    - Correct high levels of uric acid prior to treatment
- Compromised wound healing and Gastrointestinal perforation
    - Temporarily interrupt therapy for one week before major surgical procedures
- Ocular toxicity
    - Serious events leading to blindness have occurred
        - Conduct periodic comprehensive eye exams

Adverse Events

- Most common greater than or equal to 20%
    - Abdominal pain
    - Rash
    - Constipation
    - Headache
    - Dry skin
    - Arterial occlusion
    - Fatigue
    - Hypertension
    - Pyrexia
    - Arthralgia
    - Nausea
    - Diarrhea
    - Increased lipase
    - Vomiting
    - Myalgia
    - Pain in extremities

Imbruvica (ibrutinib)

Indication and Dose

- Mantle cell lymphoma (MCL) after at least one prior therapy: 560 mg PO daily
- Chronic lymphocytic leukemia (CLL)/Small lymphocytic lymphoma (SLL): 420 mg PO daily
- Chronic lymphocytic leukemia (CLL)/Small lymphocytic lymphoma (SLL) with 17p deletion: 420 mg PO daily
- Waldenström macroglobulinemia (WM): 420 mg PO daily
- Marginal zone lymphoma (MZL) who require systemic therapy and have received at least one prior anti-CD20-based therapy: 560 mg PO daily
- Chronic graft versus host disease (cGVHD) after failure of one or more lines of systemic therapy: 420 mg PO daily

Dose and Administration

- Available as 140 mg, 280 mg, 420 mg, 560 mg tablets (one pill once a day)
- Take with a glass of water
- Do not cut, crush, or chew tablets

Drug Interactions
- CYP3A Inducers: Avoid co-administration with strong CYP3A4 inducers
- CYP3A Inhibitors: Coadministration with a strong or moderate CYP3A inhibitor may increase ibrutinib concentrations. See labeling for recommendations

Mechanism of Action
- Inhibits Bruton's tyrosine kinase (BTK) by forming a covalent bond with the cysteine residue in the active site.
- BTK is a signaling molecule of the B-cell antigen receptor (BCR) and cytokine receptor pathways.
- BTK's role in signaling through the B-cell antigen receptor results in activation of pathways necessary for B-cell trafficking, chemotaxis and adhesion.

Side Effects and Management
- Hemorrhage
    - Monitor for bleeding
- Infections: Bacterial, fungal or viral
    - Monitor for fever
    - Evaluate signs of infection promptly
    - Consider prophylaxis
- Cytopenias
    - Monitor CBC monthly
- Cardiac arrythmias and hypertension
    - Monitor for symptoms of arrhythmia
    - Monitor blood pressure
- TLS
    - Assess baseline risks and take precautions
- Secondary malignancies
    - Monitor for secondary malignancies

Adverse Events
- Most common in patients with B-cell malignancies

Calquence (acalabrutinib)

Indication and Dosing
- Adult patients with mantle cell lymphoma (MCL) who have received at least one prior therapy: 100 mg PO Q12hours

Administration
- Swallow whole with water, with or without food
- Available as 100 mg capsules

Drug Interactions
- Avoid with strong CYP3A4 inhibitors or inducers
- Avoid with PPIs; stagger dosing with H2 receptor antagonists and antacids

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Mechanism of Action

- Inhibits Bruton's tyrosine kinase (BTK) by forming a covalent bond with the cysteine residue in the active site.
- BTK is a signaling molecule of the B-cell antigen receptor (BCR) and cytokine receptor pathways.
- BTK's role in signaling through the B-cell antigen receptor results in activation of pathways necessary for B-cell proliferation, trafficking, chemotaxis and adhesion

Side Effects and Management

- Hemorrhage
  - Monitor for bleeding
  - Consider holding medication three to seven days pre and post-surgery
- Infections
  - Monitor for signs/symptoms of infection
    - Treat as medically indicated
    - Consider prophylaxis
- Cytopenias
  - Monitor blood counts monthly during treatment
- Secondary primary malignancy
  - 11% of patients
  - 7% skin cancer
    - Use sun protection

Adverse Events

- Anemia
- Thrombocytopenia
- Headache
- Neutropenia
- Diarrhea
- Fatigue
- Myalgia
- Bruising

Brukinsa (Zanubrutinib)

Indications and Dosing

- Adult patients with mantle cell lymphoma (MCL) who have received at least one prior therapy: 160 mg PO BID or 320 mg PO Daily

Administration

- Swallow whole with water and with or without food
- Available as 80 mg capsules (do not chew, crush or open)

Drug Interactions

- Strong CYP3A inhibitors: Reduce dose to 80 mg PO daily
- Moderate CYP3A inhibitors: Reduce dose to 80 mg PO BID
- Strong CYP3A inducers: Avoid concomitant use

Mechanism of action

- Inhibits Bruton's tyrosine kinase (BTK) by forming a covalent bond with the cysteine residue in the active site.
- BTK is a signaling molecule of the B-cell antigen receptor (BCR) and cytokine receptor pathways
- BTK's role in signaling through the B-cell antigen receptor results in activation of pathways necessary for B-cell proliferation, trafficking, chemotaxis and adhesion

Side Effects and Management

- Hemorrhage
  - Monitor for bleeding: 2% had grade 3 or higher events; 50% had purpura and petechiae
  - Consider holding 3-7 days pre- and post-surgery
- Infections: Bacterial, viral, fungal, or opportunistic
  - Monitor for signs or symptoms and treat as medically appropriate
    - Consider prophylaxis
- Cytopenias: Anemia, neutropenia, thrombocytopenia
  - Monitor blood counts and treat using growth factor or transfusions
- Second Primary Malignancy
  - 9% of patients; 6% skin cancer. use sun protection
- Atrial fibrillation and flutter
  - Any grade 2% grade 3 in 0.6%; monitor for arrhythmias and manage as appropriate
- Most common adverse events ≥ 20 %
  - Decreased neutrophil count, platelet count, white blood cell count and hemoglobin, upper respiratory tract infection, rash, bruising, diarrhea and cough

Rydapt (midostaurin)

Indications and Dosing

- Newly diagnosed AML (Acute Myeloid Leukemia) that is FLT3 mutation positive as detected by an FDA approved test, in combination with standard daunorubicin induction, and cytarabine consolidation: 50 mg PO BID with food on days 8 to 21
- Aggressive systemic mastocytosis, systemic mastocytosis with associated hematological neoplasm (SM-AHN) or mast cell leukemia: 100 mg PO BID with food

Drug Interactions

- Strong CYP3A4 inhibitors: May increase exposure to midostaurin and its active metabolites
  - Consider alternative therapies or monitor for increased risk of adverse reactions
  - Examples: Diltiazem, posaconazole, voriconazole
- Strong CYP3A4 inducers: Avoid concomitant use as strong CYP3A4 inducers decrease exposure to midostaurin and its active metabolites
  - Examples: carbamazepine, phenytoin, rifampin

Mechanism of Action

- Midostaurin and two major metabolites inhibit multiple tyrosine kinases including wild type FLT3, mutant FLT3 kinases (ITD and TKD), KIT (wild type and D816V mutant), PDGFRα/β, VEGFR2, as well as members of the serine/threonine kinase PKC (protein kinase C) family

Side Effects and Management

- Pulmonary toxicity
    - Monitor for symptoms of interstitial lung disease or pneumonitis
    - Discontinue with s/s of interstitial lung disease or pneumonitis
- Nausea/vomiting
    - Administer prophylactic antiemetics pre-dose
- Common adverse reactions (≥20%) AML
    - Febrile neutropenia, nausea, mucositis, vomiting, headache, petechiae, musculoskeletal pain, epistaxis, device-related infection, hyperglycemia and upper respiratory tract infection
- Common adverse reactions: ≥ 20%
    - AML
        - Febrile neutropenia
        - Nausea
        - Mucositis
        - Vomiting
        - Headache
        - Petechiae
        - Musculoskeletal pain
        - Epistaxis
        - Device-related infection
        - Hyperglycemia
        - Upper respiratory tract infection
    - Aggressive systematic mastocytosis, mast cell leukemia
        - Nausea/vomiting
        - Diarrhea
        - Edema
        - Musculoskeletal pain
        - Abdominal pain
        - Fatigue
        - Upper respiratory tract infection
        - Constipation
        - Pyrexia
        - Headache
        - Dyspnea

Xospata (gilteritinib)
Indications

- Relapsed or refractory AML with a FLT3 mutation as detected by an FDA approved test

Dose and Administration

- Continue at least 6 months in absence of toxicity or disease progression
- 120 mg PO once daily with or without food
- Available as 40 mg tablets

Drug interactions

- Combined P-gp and strong CYP3A Inducers (i.e. rifampin): Avoid concomitant use
- Strong CYP3A Inhibitors: Consider alternative therapies
    - If no alternatives, monitor more frequently for adverse effects

Mechanism of Action

- Inhibits multiple tyrosine kinases including FMS-like kinase 3 (FLT3) both ITD and TKD.

Side Effect and Management

- Prolonged QT Interval
    - Monitor EKG at baseline then on days 8 and 15 of cycle one, prior to cycles two and three
    - See package insert for dose adjustments and guidance
- Pancreatitis
    - Interrupt until resolved then resume at 80 mg PO daily

Adverse Events

- Myalgia/arthralgia
- Transaminase increase
- Fatigue/malaise
- Fever
- Noninfectious diarrhea
- Dyspnea
- Edema
- Rash
- Pneumonia
- Nausea
- Stomatitis
- Cough
- Headache
- Hypotension
- Dizziness
- Vomiting

Edema or severe fluid retention (i.e. pleural effusions, pericardial effusions, ascites) can occur with TKIs used to treat CML. Which of the following could be signs of edema or fluid retention?

A. Unexpected weight gain
B. Shortness of breath
C. Ankle swelling
D. All of the above

Iressa (gefitinib)

- Initially FDA approved in 2003 for third-line treatment of NSCLC based on phase II trials
- Phase III, randomized, placebo-controlled trial of 1,692 previously treated NSCLC patients failed to show a difference in overall survival
    - No testing for EGFR mutations performed
- Approval restricted to patients benefitting from the drug in June 2005
- Re-evaluated and approved by the FDA in July 2015

Indication and Dosage

- First-line treatment for metastatic NSCLC with EGFR exon 19 deletion or exon 21 (L858R) substitution mutations as detected by an FDA-approved test
    - 250 mg PO once daily
    - With or without food
    - Available as 250 mg tablets
    - No specific hepatic dose adjustments
        - Monitor for toxicity in liver impairment

Drug interactions

- Strong CYP3A4 inducers: Increase gefitinib to 500 mg PO daily
- CYP3A4 inhibitors: Monitor for increased toxicities of gefitinib
- Drugs affecting gastric pH: Avoid use of gefitinib with PPIs
    - Take 12 hours before or after PPI
    - Take 6 hours before or after H2 blocker or antacid
- Warfarin: Increases in INR and hemorrhage have been reported

Mechanism of Action

- Inhibits EGFR: Wild type and exon 19 /exon 21 mutated forms via reversible inhibition which blocks auto phosphorylation
- This blocks tumor growth, causes apoptosis, and prevents angiogenesis and metastasis of cancer cells

Side Effects and Management

- Interstitial lung disease (ILD), lung infiltration, pneumonitis, acute respiratory disease syndrome, pulmonary fibrosis
    - Withhold if patient presents with cough, dyspnea or fever
    - ILD confirmed discontinue medication permanently
- Hepatotoxicity
    - Monitor LFTs periodically and withhold for grade two or higher ALT/AST elevations
    - Discontinue for severe toxicity
- Diarrhea: Severe or persistent
    - Withhold for grade 3 or 4 diarrhea
- Ocular disorders including keratitis
    - Discontinue if severe or worsening
- Common Toxicities
    - Skin reactions
    - Diarrhea
- Severe Rare Toxicities
    - Toxic epidermal necrolysis (TEN)
    - Stevens-Johnson syndrome (SJS)
    - Erythema multiforme
    - GI perforation

Tarceva (erlotinib)

Indications and Dose

- Metastatic NSCLC with EGFR exon 19 deletion or exon 21 (L858R) substitution mutations as detected by an FDA-approved test receiving first-line, maintenance, second or greater line treatment after progression following at least one prior chemotherapy regimen: 150 mg PO
- First-line treatment, in combination with gemcitabine, for patients with locally advanced unresectable or metastatic pancreatic cancer: 100 mg PO

Administration

- Take on an empty stomach at least 1 hour before or 2 hours after food
- Available as 25 mg, 100 mg and 150 mg tablets

Drug Interactions

- Strong CYP3A4 inhibitors: avoid use and if not possible, reduce dose of erlotinib
- CYP3A4 inducers: Avoid if possible or consider increasing dose
- If patient continues to smoke, consider increasing to 300 mg daily
- Monitor PT/INR closely if concomitant warfarin
- Avoid use of PPIs; if H2 antagonist used give erlotinib 10 hours after the H2 antagonist and at least 2 hours before a second dose of the H2 antagonist

Mechanism of Action

- Reversibly inhibits the EGFR tyrosine kinase by competitively inhibiting binding of ATP
- Results in inhibition of critical mitogenic and anti-apoptotic signals involved in proliferation, growth, metastasis, and angiogenesis

Side Effects and Management

- Skin rash
    - Topical clindamycin
    - Oral minocycline/doxycycline
    - If severe reaction discontinue medication
- Diarrhea
    - Loperamide
        - If unresponsive to loperamide consider dose reduction
- ILD
    - Manifests as increased cough
    - Dyspnea
    - Fever and pulmonary infiltrates
    - Discontinue medication
- Corneal perforation/ulceration/persistent severe keratitis
    - Interrupt or discontinue in patients with acute or worsening eye pain

Rare Side Effects

- Renal/hepatic failure
- GI perforation
- Myocardial infarction (MI)
- Cerebrovascular accident (CVA)
- Microangiopathic hemolytic anemia

Gilotrif (afatinib)

Indication and Dose

- First line treatment of metastatic NSCLC with non-resistant EGFR mutations as detected by an FDA approved test
    - 40 mg PO once daily
    - 1 hour before or 2 hours after a meal
    - Available as 20 mg, 30 mg and 40 mg tablets
- Metastatic, squamous NSCLC progressing after platinum-based chemotherapy
    - 40 mg PO once daily
    - 1 hour before or 2 hours after a meal
    - Available as 20 mg, 30 mg and 40 mg tablets

Drug Interactions

- Co-administration of p-glycoprotein inhibitors can increase afatinib exposure
  - Reduce by 10mg/day if not tolerated
- Co-administration of p-glycoprotein inducers can decrease afatinib exposure
  - Increase by 10mg/day as tolerated
- Covalent adducts to proteins are the major metabolites
- Enzymatic metabolism is minimal

Mechanism of Action

- Resulting in down regulation of ERB signaling
- Covalently binds to the kinase domains of EGFR (ErbB1), HER2 (ErbB2) and HER4 (ErbB4)
- Irreversibly inhibits kinase auto phosphorylation

Side Effects and Management

- Diarrhea
  - Antidiarrheals
  - Fluid and electrolyte replacement
  - Hold medication if severe
- Keratitis
  - Withhold or discontinue for confirmed ulcerative keratitis
- ILD
  - Withhold for acute onset or worsening of pulmonary symptoms
  - Discontinue if ILD diagnosed
- Hepatic toxicity
  - Monitor with periodic liver enzyme testing
  - Withhold or discontinue for severe or worsening liver function tests

Tagrisso (osimertinib)

Indications

- First line treatment of metastatic NSCLC with EGFR exon 19 deletion or exon 21 L858R substitution mutation as detected by an FDA approved test
- Metastatic EGFR T790M mutation positive NSCLC (as detected by an FDA approved test) who have progressed on or after EGFR TKI therapy

Dose and Administration

- 80 mg PO once daily
- With or without food
- 40 mg and 80 mg tablets
  - Can be dissolved in 2 ounces of water then added to another 4 to 8 ounces if difficulty swallowing

Drug Interactions
- Strong CYP3A4 Inducers: Avoid if possible
- Avoid with drugs known to prolong QTc interval

Mechanism of Action
- Irreversibly binds and inhibits mutant forms of EGFR including exon 19 deletion, L858R, T790M as well as wild type EGFR
- Binds to mutant EGFR at approximately 9-fold lower concentrations than wild-type

Side Effects and Management

Side Effects	Management
Diarrhea	• Anti-diarrheal • Fluid and electrolyte replacement • Hold medication if severe
Bullous and exfoliative skin disorders	• Hold for severe or prolonged cutaneous reactions • Discontinue if life-threatening cutaneous reactions
ILD	• Withhold for acute onset or worsening of pulmonary symptoms • Discontinue if ILD diagnosed
Hepatic toxicity	• Monitor with periodic liver enzyme testing • Withhold or discontinue for severe or worsening liver function tests

Vizimpro (dacomitinib)
- First line treatment of metastatic NSCLC with EGFR exon 19 deletion or exon 21 L858R substitution mutations as detected by an FDA approved test

Dose and Administration
- 45 mg PO once daily
- With or without food
- Available as 15 mg, 30 mg, and 45 mg tablets

Drug Interactions
    - Proton Pump Inhibitors (PPIs): Avoid use
    - Administer dacomitinib at least 6 hours before or 10 hours after H2-receptor antagonist
- CYP2D6 Substrates: Avoid concomitant use where minimal increases in the concentration of the CYP2D6 substrate may lead to serious or life-threatening consequences

Mechanism of Action

- Irreversible inhibitor of the kinase activity of the human EGFR family
  - EGFR/HER1, HER2, and HER4
- Certain EGFR activating mutations
  - Exon 19 deletion or the exon 21 L858R substitution mutation

Side Effects and Management

ILD	• Permanently discontinue if confirmed
Diarrhea	• Withhold or dose reduce • Promptly initiate loperamide or Lomotil
Dermatologic • Rash • Exfoliative skin reactions	• Withhold or reduce dose based upon severity • Use moisturizers and avoid sun exposure • Topical or oral antibiotics or topical steroids depending on grade

EGFR inhibitors can commonly cause acne-like skin rashes. Which of the following is most often used to address this toxicity?

A. Cephalexin
B. Doxycycline
C. Benzoyl peroxide topically
D. Hydrocortisone 1% cream
E. Sulfamethoxazole/Trimethoprim

Tyrosine Kinase Inhibitors: Part 2

Background information

- Strong CYP 3A4 inhibitors
  - Azole antifungals: Ketoconazole, posaconazole, voriconazole
  - Protease inhibitors: Ritonavir, darunavir, lopinavir, nelfinavir, etc.
  - Clarithromycin
- Strong CYP 3A4 inducers
  - Barbie's Car Goes Really Phast
    - B = Barbiturates
    - S = St. John's Wort
    - C = Carbamazepine
    - G = Griseofulvin
    - R = Rifampin
    - Ph = Phenytoin

ALK Mutation

- Arises from an inversion on the short arm of chromosome 2 to EML4
- EML4-ALK fusion oncogene activates signaling cascades leading to cell survival and proliferation
- Present in 3-7% of non-small cell lung cancer (NSCLC)

Crizotinib

- FDA approval
  - First line ALK+ or ROS1 mutated metastatic non-small cell lung cancer (mNSCLC)
- Dose
  - 250 mg PO twice daily
- Drug interactions
  - CYP3A4 substrate and inhibitor
  - Avoid strong 3A4 substrates/inhibitors
- Renal dysfunction
  - Creatinine clearance (CrCl) ≥ 30: No adjustments
  - CrCl < 30: Reduce 250mg once daily
- Hepatic dysfunction
  - Mild: None
  - Moderate: 200 mg BID
  - Severe: 250 mg once daily
    - Treatment modifications exist if hepatotoxicity is developed during therapy

Ceritinib

- FDA approval
  - First line ALK+ mNSCLC or after crizotinib progression
- Dose
  - 750 mg PO once daily
- Drug interactions
  - Avoid strong CYP3A4 inhibitors/ inducers
  - Adjust dose if possible interaction unavoidable
- Renal dysfunction
  - CrCl ≥ 30: No adjustments
  - CrCl < 30: Has not been studied

Alectinib

- FDA approval
  - First line ALK+ mNSLCL or after crizotinib progression
- Dose
  - 600 mg PO twice daily
- Drug Interactions
  - None
- Renal dysfunction
  - CrCl ≥ 30: No adjustments
  - CrCl < 30: Has not been studied
- Hepatic dysfunction
  - Mild: None
  - Moderate: None
  - Severe: Reduce 450 mg twice daily
    - Treatment modifications exist if hepatotoxicity is developed during therapy

Brigatinib

- FDA Approval
  - First line ALK+ mNSLCL or after crizotinib progression
- Dose
  - 90 mg po daily: Days 1-7, increase after day 7 to 180 mg PO daily if tolerated
- Drug interactions
  - Avoid use with strong CYP3A4 inhibitors and inducers
    - Adjust dose if possible interaction unavoidable
- Renal dysfunction
  - CrCl ≥ 30: No adjustments
  - CrCl 15- < 30: Reduce dose by approximately 50%
    - 180mg to 90 mg, and then 90 mg to 60 mg
- Hepatic dysfunction
  - Mild: None
  - Moderate: None
  - Severe: Reduce dose by approximately 40%
    - 180 mg to 120 mg, then 120 mg to 90 mg, finally 90 mg to 60 mg

Lorlatinib

- FDA approval
  - Second line or beyond ALK+ mNSCLC
- Dose
  - 100 mg po daily
- Drug interactions
  - 100 mg po daily
- Drug interactions
  - CYP3A4 inducers, inhibitors, and substrates
    - Decrease dose to 75mg with strong 3A4 inhibitors
- Renal dysfunction
  - CrCl ≥ 30: No adjustments
  - CrCl < 30: Has not been studied
- Hepatic dysfunction
  - Mild: None
  - Moderate: Has not been studied
  - Severe: Has not been studied
  - Treatment modifications exist if hepatotoxicity is developed during therapy

ALK Inhibitors Adverse Events

- ILD/pneumonitis: Brigatinib, crizotinib, ceritinib, lorlatinib, alectinib
- Hepatotoxicity
  - Check LFTs and bilirubin at baseline and throughout treatment
    - Alectinib: Typically occurs within the first 2 months
    - Brigatinib: Does not cause hepatotoxicity
- Bradycardia
  - If asymptomatic dose modification is not required
  - If symptomatic
    - Hold therapy until patient is asymptomatic or HR is > 60
      - Evaluation for other medication causes: Beta blockers, digoxin, etc.
      - Resume at reduced dose
- QTc prolongation
  - Correct electrolytes prior to therapy initiation
  - Conduct baseline EKG and periodically throughout treatment
  - Hold therapy for QTc > 500
    - Alectinib and brigatinib are the exceptions and do not cause meaningful QTc prolongation
- Vision disorders
  - Can manifest as blurred vision, floaters, visual impairment, reduced visual acuity, asthenopia, and diplopia
    - Patients should have baseline visual exam and repeat with any symptoms

- Myalgias/Musculoskeletal pain
    - Advise patients to report any unexplained muscle pain or weakness
        - Alectinib
            - Mild symptoms are common 29%
            - Severe symptoms occurred in approximately 1% of patients
            - CPK elevations may occur with median time to Grade 3 elevation of 14 days
            - Monitor CPK levels every 2 weeks for the first month then as clinical indicated

Agent Specific Adverse Effects

- Alectinib: Can cause photosensitivity
    - Patient should protect skin from sunlight and wear SPF ≥ 30 sunscreen
- Ceritinib: Can cause severe GI toxicity
    - Nausea, vomiting, diarrhea, or abdominal pain occurred in 95% of patients
        - 14% of patients experienced grade 3 or 4 GI toxicity
        - Manage with antiemetics and anti-diarrheal agents
        - IV fluids may be needed to prevent dehydration
    - Hyperglycemia
        - Monitor glucose closely in those with and without diabetes
    - Pancreatitis
- Brigatinib
    - Hyperglycemia
    - Pancreatitis
    - Hypertension
- Lorlatinib
    - Central nervous system effects 54%
    - Cognitive, mood, and speech effects
    - Hallucinations
    - Seizures

VEGF Inhibitors

- Mechanism of Action
    - Normally is well controlled by pro- and anti-angiogenic factors and is only promoted during events
    - Angiogenesis plays a critical step in tumor progression
    - New blood vessel growth is required for growth of tumor cells and metastasis formation
    - VEGF signaling is the major inducer of angiogenesis
    - VEGF inhibitors block angiogenesis

Sorafenib

- FDA approval
  - Unresectable hepatocellular carcinoma
  - Metastatic renal cell carcinoma (mRCC)
  - Locally recurrent or metastatic, progressive, differentiated thyroid carcinoma refractory to radioactive iodine treatment
- Dose
  - 400 mg twice a day
- Drug interactions
  - CYP3A4 inducers: Increase metabolism of sorafenib
- Renal dysfunction
  - CrCl 20-39 mL/min: 200 mg PO BID
  - CrCl <20 mL/min: Insufficient data
  - Hemodialysis: 200 mg PO Daily

Sunitinib

- FDA approval
  - Adjuvant renal cell carcinoma and mRCC
  - Gastrointestinal stromal tumor (GIST) tumors after progression/intolerance to imatinib
  - Locally advanced or metastatic pancreatic neuroendocrine ca (pNET)
- Dose
  - RCC/GIST: 50 mg daily for 4 weeks on followed by 2 weeks off
  - pNET: 37.5 mg daily without breaks
- Drug Interactions
  - Consider dose adjustments with strong CYP3A4 inhibitors and inducers
- Renal dysfunction
  - None
- Hepatic dysfunction
  - Mild-moderate: None
  - Severe: Not studied

Pazopanib

- FDA approval
  - mRCC
  - Advanced soft tissue sarcoma after prior chemotherapy
- Dose
  - 800 mg daily
- Drug interactions
  - Strong CYP3A4 inhibitors: Avoid or reduce to 400 mg daily
  - Strong CYP3A4 inducers: Do not use pazopanib if chronic CYP3A4 inducers cannot be avoided
- Renal dysfunction
  - None

- Hepatic dysfunction
    - Moderate: 200 mg PO Daily
    - Severe: Do not use

Axitinib

- FDA approved
    - mRCC after failure on at least one other therapy
- Dose
    - 5 mg PO BID with or without food
    - Increase to 7 mg PO BID and then to 10 mg PO BID if tolerated
- Drug Interactions
    - Strong 3A4 inhibitors: Decrease dose by approximately 50%
- Renal dysfunction
    - CrCl > 15: Not applicable
- Hepatic dysfunction
    - Moderate: Reduce starting dose by 50%
    - Severe: Has not been studied

Regorafenib

- FDA approval
    - Metastatic colon cancer previously treated with fluoropyrimidine, oxaliplatin and irinotecan-based chemotherapy, anti-VEGF therapy and if KRAS wild type an anti-EGFR therapy
    - Locally advanced, unresectable or metastatic (GIST) previously treated with imatinib or sunitinib
    - Hepatocellular carcinoma (HCC) previously treated with sorafenib
- Dose
    - 160 mg PO daily with a low-fat breakfast day 1-21 of 28 day cycle
    - Alternative: With weekly dose escalation from 80 mg to 120 mg to 160 mg
        - Improved overall survival, tolerability, quality of life
    - Available as 40 mg tablets
        - Store in original manufacturer's container
        - Dispose of any unused tablets 28 days after opening
- Dose interactions
    - Avoid concomitant strong CYP3A4 inducers or inhibitors
- Renal dysfunction
    - Not applicable
- Hepatic dysfunction
    - Mild-moderate: No dose adjustments but monitor closely
    - Severe: Use is not recommended
        - Has not been studied

VEGF Inhibitors-Toxicities

Side Effects	Possible Management
GI perforations and fistulas	• Discontinue therapy
Hemorrhages	• Severe, sometimes fatal, hemorrhage including hemoptysis and gastrointestinal hemorrhage may occur ○ Monitor for signs of bleeding
Venous and arterial thromboembolic events	• Discontinue if acute myocardial infarction or other clinically significant arterial thrombotic event occurs
Wound healing	• Hold prior to surgery; resume based on clinical judgment ○ Refer to the specific package insert/recommendations for each agent
Hypertension	• Reduced angiogenesis leads to vasoconstriction and hypertension. Hypertension can be seen within days of starting therapy, axitinib ○ Monitor closely throughout therapy and treat as needed
Cardiac	• May cause cardiomyopathy, cardiac ischemia or myocardial infarcts • Check LVEF prior to initiation of therapy and during treatment ○ Hold or discontinue for reductions in LVEF, ischemia or MI

Proteinuria	• Check urinalysis at baseline and during treatment
	  ○ Can cause nephrotic syndrome and lead to renal dysfunction
	  ○ May need to hold therapy for proteinuria

Hypothyroidism	• Check thyroid function tests prior to initiation and throughout therapy ○ Treat at necessary

Agent Specific Adverse Effects

- Sorafenib
  - Hand-foot syndrome
- Sunitinib
  - QTc prolongation
  - Adrenal insufficiency
- Pazopanib
  - QTc prolongation
- Axitinib
  - Hepatotoxicity
  - Reversible posterior leukoencephalopathy syndrome (RPLS)
- Regorafenib
  - Hand-foot syndrome
  - RPLS

Patients treated with TKIs that inhibit VEGF often develop hypertension. When starting a patient on axitinib what should the providers keep in mind?

A. Check baseline blood pressure
B. Monitor blood pressure routinely
C. Add anti-hypertensives if patient develops hypertension
D. BP increases are usually seen in the first month
E. All of the above

MET/RET Inhibitors

Cabozantinib

- FDA Approval
  - Progressive, metastatic medullary thyroid cancer (MTC)
  - 1st line metastatic renal cell carcinoma (RCC)
  - Advanced RCC after prior anti-angiogenic therapy
  - Hepatocellular carcinoma (HCC) after prior sorafenib
- Targets
  - MET, VEGFR2, FLT3, KIT, AXL, RET
- Dose
  - MTC: 140 mg PO daily on an empty stomach
  - RCC/HCC: 60 mg PO daily on an empty stomach
- Drug Interactions
  - Strong CYP3A4 inhibitors
    - MTC: Decrease dose by 40 mg
    - RCC/HCC: Decrease dose by 20 mg
  - Strong CYP3A4 inducers
    - MTC: Increase dose by 40 mg
    - RCC/HCC: Increase dose by 20 mg

- Renal Dysfunction
    - CrCl ≥ 30 ml/min: No dose adjustments
    - CrCl <30 ml/min: Hasn't been studied
- Hepatic Dysfunction
    - Mild impairment
        - MTC: Decrease initial dose to 80 mg daily
        - RCC/HCC: No dose adjustment necessary
    - Moderate impairment
        - MTC: Decrease initial dose to 80 mg daily
        - RCC/HCC: Decrease initial dose to 40 mg daily
    - Severe impairment
        - Use is not recommended as it hasn't been studied

Lenvatinib

- FDA approval
    - Locally recurrent or metastatic, progressive, radioactive iodine-refractory differentiated thyroid cancer (DTC)
    - Advanced renal cell cancer (RCC) after one prior anti-angiogenic therapy in combination with everolimus
    - First line unresectable HCC
    - In combination with pembrolizumab for advanced endometrial cancer that is not microsatellite instability high (MSI-H) or deficient mis – match repair (dMMR) who have progressed on prior systemic therapy and are not candidates for curative surgery or radiation
- Targets
    - RET, VEGFR1,2 and 3, FGFR, PDGFR-alpha, c-KIT
- Dose
    - DTC: 24 mg po once daily with or without food
    - RCC: 18 mg po once daily with or without food in combination with everolimus 5mg po once daily
    - HCC: Dosage is based on actual body weight
        - ≥ 60kg: 12 mg PO daily with or without food
        - < 60kg: 8 mg PO daily with or without food
    - Endometrial: 20 mg PO daily with pembrolizumab 200 mg IV every 3 weeks
- Drug Interactions
    - No significant CYP enzyme or efflux pump interactions
    - Can increase the QTc
        - Avoid concomitant medications that can prolong the QTc
- Renal Dysfunction
    - CrCl ≥ 30 ml/min: no dose adjustments
    - CrCl < 30 ml/min
        - DTIC: 14 mg once daily
        - RCC: 10 mg once daily
        - HCC: No adjustments
        - Endometrial: 10 mg once daily

- Hepatic Dysfunction
    - Mild impairment
        - No dose adjustment necessary
    - Moderate impairment
        - No dose adjustment necessary
    - Severe impairment
        - DTIC: 14 mg once daily
        - RCC: 10 mg once daily
        - HCC: no recommendations provided
        - Endometrial: 10 mg once daily

MET/RET Inhibitor Toxicities

Side Effect	Possible Management
GI perforations and fistulas	• Discontinue therapy
Hemorrhages	• Severe, sometimes fatal, hemorrhage including hemoptysis and gastrointestinal hemorrhage may occur o Monitor for signs of bleeding
Venous and arterial thromboembolic events	• Discontinue if acute myocardial infarction or other clinically significant arterial thrombotic event occurs
Wound healing	• Hold 28 days prior to surgery; resume based on clinical judgment
Hypertension	• Monitor blood pressure prior to initiation and regularly during treatment; discontinue for hypertensive crisis
Osteonecrosis of the jaw	• Perform an oral examination prior to and periodically during treatment; withhold 28 days prior to dental surgery if possible
Palmer-Planter Erythrodysesthesia syndrome	• Withhold until grade 1 and then at a reduced dose
Proteinuria	• Monitor urine protein and discontinue if nephrotic syndrome develops
RPLS	• Evaluate for RPLS if seizures, headache, visual disturbances, confusion or altered mental status develops
Hypocalcemia	• Monitor blood calcium levels at least monthly and replace calcium as necessary

BRAF Inhibitors

Mechanism of Action

- Inhibits some mutated forms of BRAF serine threonine kinase including $BRAF^{V600E}$
- Some mutations in BRAF including V600E result in constitutively activated BRAF proteins, which can cause cell proliferation in the absence of growth factors needed for proliferation

Vemurafenib

- FDA approval
  - BRAF V600E mutated metastatic melanoma as a single agent or in combination with the MEK inhibitor cobimetinib
- Dose
  - 960 mg po twice daily
- Administration
  - With or without food
- Renal dysfunction
  - No dose adjustments provided (hasn't been studied) though minimal (1%) elimination via urine
- Hepatic dysfunction
  - No dose adjustments provided (hasn't been studied)
- Drug Interactions
  - Substrate CYP3A4: Avoid strong 3A4 inhibitors/inducers
  - Inhibitor CYP1A2: Avoid drugs with narrow therapeutic index predominately metabolized by 1A2 or monitor closely
  - Inhibitor of P-gp: Avoid drugs that have a narrow therapeutic index and are a substrate of P-gp
    - Consider alternative agent or dose reductions

Dabrafenib

- FDA approvals
  - BRAF V600E mutated metastatic melanoma as a single agent or in combination with trametinib
  - Adjuvant therapy in BRAF V600E or K mutated, fully resected stage III melanoma, in combination with the MEK inhibitor trametinib
  - Metastatic NSCLC with BRAF V600E mutation in combination with trametinib
  - BRAF V600E mutated locally advanced or metastatic anaplastic thyroid cancer (ATC)
- Dose
  - 150 mg po twice daily
- Administration
  - Empty stomach
    - One hour before or two hours after a meal
- Renal Dysfunction
  - None

- Hepatic Dysfunction
    - Mild impairment
        - None
    - Moderate-severe impairment
        - No dose adjustments provided, however hepatic metabolism and biliary excretion are primary elimination routes, and exposure may be increased with moderate-severe hepatic impairment
- Drug Interactions
    - Substrate CYP3A4 and 2C8: Avoid strong 3A4 or 2C8 inhibitors
        - If not possible, monitor closely for toxicity
    - Inducer of CYP3A4, CYP2C8, CYP2C9, CYP2C19, and CYP2B6: may result in decreased efficacy of medications metabolized by these enzymes

Encorafenib

- FDA approval
    - BRAF V600E or V600K mutated unresectable or metastatic melanoma in combination with the MEK inhibitor binimetinib
    - BRAF V600E mutated metastatic colorectal cancer after prior therapy in combination with cetuximab
- Dose
    - 450 mg once daily
- Administration
    - With or without food
- Renal dysfunction
    - CrCl ≥ 30 mL/min: none
    - CrCl < 30: hasn't been studied
- Hepatic dysfunction
    - Mild impairment
        - None
    - Moderate-severe impairment
        - Hasn't been studied
    - Treatment modifications exist if hepatotoxicity is developed during therapy
- Drug Interactions
    - Substrate CYP3A4: Avoid moderate and strong 3A4 inhibitors
        - If unable to avoid, reduce dose of encorafenib
    - Strong CYP3A4 inducers may reduce encorafenib drug levels; avoid concomitant use
    - Encorafenib may make oral contraceptives less effective

BRAF Inhibitors – Adverse Effects

Side Effect	Possible Management
Cutaneous squamous cell carcinoma	• Preform dermatologic evaluations prior to initiation of therapy and every two months while on therapy • Manage with excision and continue treatment without dose adjustments
Severe hypersensitivity reactions	• Do not re-challenge: Discontinue
Stevens-Johnson syndrome Toxic epidermal necrolysis	• Discontinue if sever skin reaction
LFT abnormalities	• Monitor liver enzymes at baseline and monthly during treatment
Ocular toxicities: uveitis	• Preform ophthalmologic exam for any visual disturbance
Arthralgias	• Manage symptomatically

Vemurafenib

- Severe photosensitivity: Advise patients to wear sunscreen with sun protection factor (SPF) ≥ 30-year round
- QTc prolongation: Monitor EKG and electrolytes at baseline and after dose adjustments
    - Monitor EKG at day 15, monthly for the first 3 months, then every 3 months
- LFT abnormalities: Monitor liver enzymes at baseline and monthly during treatment

Dabrafenib

- Hemorrhage: Occurred in combination with trametinib
    - Monitor for signs and symptoms of bleeding
- Venous thromboembolism
    - DVT and PE can occur with the combination of dabrafenib and trametinib
    - Monitor for shortness of breath (SOB), leg pain
- Cardiomyopathy
    - Assess LVEF at baseline, after 1 month then every 2 to 3 months when using the combination
- Serious febrile drug reactions
    - Withhold if fever ≥ 101.3°F occurs or if complicated fever rigors, hypotension, renal failure, dehydration
        - More common with trametinib combination
        - For fevers lasting ≥ 3 days or pyrexia with complications
            - Dehydration, hypotension, renal failure administer corticosteroids
- Hyperglycemia
    - Monitor blood glucose levels in patients with pre-existing diabetes or hyperglycemia
- Glucose 6-phosphate dehydrogenase deficiency
    - Monitor closely for hemolytic anemia
- Hand foot syndrome

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Encorafenib

- Hemorrhage: Monitor for signs and symptoms of bleeding
- QTc prolongation: Monitor EKG and electrolytes at baseline and after dose adjustments
    - Monitor EKG at day 15, monthly for the first 3 months, then every 3 months
    - Correct electrolytes: Potassium > 4, Magnesium > 2 and hold for QTc >500 msec

MEK Inhibitors

- Mechanism of Action
    - Reversible inhibition of MEK1 and MEK2: Upstream regulators of the ERK pathway
    - BRAF mutations cause constitutive activation of the BRAF pathway which includes MEK1 and MEK2

Cobimetinib

- FDA approval
    - Unresectable or metastatic melanoma with a BRAF V600E or V600K mutation in combination with vemurafenib
- Dose
    - 60 mg PO daily days 1-21 of a 28-day cycle in combination with vemurafenib
- Administration
    - With or without food
- Renal dysfunction
    - CrCl ≥ 30 mL/min: None
    - CrCl < 30: Hasn't been studied minimal urinary excretion
- Hepatic dysfunction
    - Mild, Moderate, Severe impairment: No initial dose adjustment is necessary
    - Treatment modifications exist if hepatotoxicity is developed during therapy
- Drug interactions
    - Substrate CYP3A4
        - Avoid moderate/strong CYP3A4 inhibitors
        - If short term use ≤ 14 days is unavoidable in those taking cobimetinib 60mg, reduce cobimetinib to 20mg daily
        - Avoid moderate/strong CYP3A4 inhibitors on those already on a reduced dose of cobimetinib
    - Strong CYP3A4 inducers may decrease cobimetinib exposure by more than 80%
        - Avoid concurrent use.

Trametinib

- FDA approvals
    - As a single agent in BRAF V600E mutated metastatic melanoma or in combination with the BRAF inhibitor dabrafenib
    - Adjuvant therapy in BRAF V600E or K mutated, fully resected stage III melanoma, in combination with the BRAF inhibitor dabrafenib
    - Metastatic NSCLC with BRAF V600E mutation in combination with BRAF inhibitor dabrafenib

- Dose
  - 2 mg PO daily with or without dabrafenib
- Administration
  - Empty stomach
    - 1 hour before or 2 hour after a meal
- Renal dysfunction
  - CrCl ≥ 30 mL/min: None
  - CrCl <30: Hasn't been studied minimal urinary excretion
- Hepatic Dysfunction
  - Mild impairment- none
  - Moderate to severe impairment: No dose adjustments provided
    - An appropriate dose has not been established
- Drug Interactions
  - No clinically relevant drug interactions

Binimetinib

- FDA approvals
  - BRAF V600E or V600K mutated unresectable or metastatic melanoma in combination with the BRAF inhibitor encorafenib
- Dose
  - 45 mg PO twice daily in combination with encorafenib
- Administration
  - With or without food
- Renal dysfunction
  - No dose adjustments
- Hepatic dysfunction
  - Mild impairment, Child-Pugh A: None
  - Moderate-severe impairment, Child-Pugh B-C: Decrease to 30 mg PO twice daily
  - Treatment modifications exist if hepatotoxicity is developed during therapy
- Drug interactions
  - No clinically relevant drug interactions

MEK Inhibitors Adverse Effects

Side Effects	Possible Management
New primary malignancies cutaneous and non-cutaneous	• Perform dermatologic evaluations prior to initiation of therapy and every 2 months while on therapy • Manage with excision and continue treatment without dose adjustments
Hemorrhage	• Rare; monitor for signs and symptoms of bleeding
Cardiomyopathy	• Evaluate LVEF at baseline, after 1 month and then every 2-3 months
Severe rash or skin toxicity	• Interrupt, reduce or discontinue

_____
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Ocular toxicity including serous retinopathy and retinal vein occlusion	• Perform eye evaluations at regular intervals and for any visual disturbances

Cobimetinib

- Rhabdomyolysis
  - Obtain baseline CPK and periodically monitor as clinically indicated
- Severe photosensitivity
  - Avoid sun exposure, wear protective clothing and use UVA/UVB sunscreen and lip balm SPF ≥ 30
- Hepatotoxicity
  - Monitor LFTs at baseline and monthly or more frequently if indicated

Trametinib

- Venous thromboembolism
  - DVT and PE can occur with the combination of dabrafenib and trametinib
- Interstitial lung disease (ILD)
  - Hold for new or progressive unexplained pulmonary symptoms
    - Discontinue if treatment related ILD or pneumonitis diagnosed
- Serious febrile drug reactions
  - Withhold if fever >104°F occurs or if complicated fever, rigors, hypotension, renal failure, dehydration
- Serious skin toxicity
  - Discontinue for intolerable grade 2, 3, or 4 rash not improving within 3 weeks despite interruption of therapy
- Hyperglycemia
  - Monitor blood glucose levels in patients with pre-existing diabetes or hyperglycemia

Binimetinib

- Venous thromboembolism
  - DVT and PE occurred in 6% and 3.1% of patients, respectively
    - Withhold, reduce dose, or permanently discontinue based on severity of symptoms
- ILD
  - Hold for new or progressive unexplained pulmonary symptoms
    - Discontinue if treatment related ILD or pneumonitis diagnosed
- Transaminitis
  - Monitor LFTs at baseline, and monthly, and as clinically indicated
- Hemorrhage
  - Grade 3 or 4 hemorrhage in approximately 3% of patients including GI bleeds, rectal bleed, or hematochezia
  - Fatal intracranial hemorrhage in the setting of new or progressive brain metastasis occurred in 1.6% of patients

- Rhabdomyolysis
    - Obtain baseline CPK and periodically monitor as clinically indicated

Melanoma patients treated with BRAF inhibitors can develop new squamous cell carcinomas (SCC) of the skin. If this happens in a patient on vemurafenib and cobimetinib which of the following should be done?

A. No intervention
B. Change therapy to dabrafenib/trametinib
C. Refer to dermatology to excise the SCC
D. Stop the BRAF inhibitor immediately
E. Change therapy to pembrolizumab

HER2 Inhibitors

Lapatinib (Tykerb)

- Indicated in combination with
    - Capecitabine, for the treatment of patients with advanced or metastatic breast cancer whose tumors overexpress HER2 and who have received prior therapy including an anthracycline, a taxane, and trastuzumab
    - Letrozole for the treatment of postmenopausal women with hormone receptor positive metastatic breast cancer that overexpresses the HER2 receptor for whom hormonal therapy is indicated
- Dosing
    - For advanced or metastatic breast cancer: 1,250 mg PO once daily on Days 1-21 continuously in combination with capecitabine 2,000 mg/m^2/day
        - Administered orally in 2 doses approximately 12 hours apart on days 1-14 in a repeating 21-day cycle
    - For hormone receptor positive, HER2 positive metastatic breast cancer
        - 1500 mg po once daily continuously in combination with letrozole
- Administration
    - Take one hour before or one hour after a meal
    - Given once daily, do not divide doses
    - Available as 250 mg tablets
- Dose Adjustments
    - Strong CYP3A4 inhibitor
        - Avoid concomitant use or consider dose reduction to lapatinib 500 mg daily
    - Strong CYP3A4 inducer
        - Avoid concomitant use or consider dose increase up to 4500 mg daily or 5500 mg daily as tolerated
    - Severe hepatic impairment per Child Pugh Class C
        - Decrease by 500 mg to 750 mg or 1000 mg daily
    - Cardiac events
        - Discontinue if LVEF decrease is ≥ Grade 2 or below institutional lower limit of normal

- Drug Interactions
    - CYP3A4 inhibitors or inducers
    - CYP2C8 substrates such as paclitaxel

Mechanism of Action

- Reversibly and competitively inhibits the intracellular tyrosine kinase domains of both EGFR and human epidermal receptor type 2: HER2
- Results in inhibition of critical mitogenic and anti-apoptotic signals involved in proliferation, growth, metastasis, and angiogenesis

Neratinib

- Indication
    - Adjuvant therapy for early stage HER2 positive breast cancer after completion of adjuvant trastuzumab
    - In combination with capecitabine, for the treatment of adult patients with advanced or metastatic HER2-positive breast cancer who have received two or more prior anti-HER2 based regimens in the metastatic setting
- Dosing
    - Adjuvant therapy: 240 mg given orally once daily with food, continuously for one year
    - Metastatic therapy: 240 mg given orally once daily with food, continuously
- Drug Interactions
    - Acid suppressors: Avoid use of PPI's and H2 antagonists
        - May use antacids but need to separate the dose by at least 3 hours
    - Moderate/strong CYP3A4 inhibitors: Avoid concomitant use
    - Moderate/strong CYP3A4 inducers: Avoid concomitant use
    - P-glycoprotein substrates: Monitor for adverse reactions of P-gp substrates with narrow therapeutic indexes (digoxin, dabigatran)
- Mechanism of Action
    - Irreversibly binds to HER2 and HER4, reducing EGFR and HER2 autophosphorylation and downstream MAPK and AKT signaling

HER2 Inhibitors Side Effects and Management

Side Effect	Possible Management

Diarrhea	• Provide loperamide prophylaxis during the 1st 2 cycles (56 days) of treatment.
	  ○ Day 1-14: 4 mg PO TID
	  ○ Day 15-28: 4 mg PO BID
	  ○ Day 29+: as needed
	• Neratinib dose adjustments exist for diarrhea

Hepatotoxicity	• Monitor LFTs at baseline and every month for the 1st 3 months then every 3 months while on treatment
Stomatitis	• Encourage good oral hygiene

Understanding Toxicity: Management and Adverse Events of Chemotherapy

Common Terminology Criteria for Adverse Events (CTCAE)

- Commonly called the common toxicity criteria
- Standardized definitions used to describe the severity of organ toxicity for patients receiving cancer treatments
- The criteria is used for
    - Management of therapy administration
    - Dosing and in clinical trials to provide standardization
    - Consistency in the definition of treatment related toxicity

What Defines an Adverse Event

- Any unfavorable or unintended sign or symptom, illness or disease associated with the treatment, even if it is temporary

Toxicity Grading

- Grade 1: Mild
- Grade 2: Moderate
- Grade 3: Severe
- Grade 4: Life threatening
- Grade 5: Death

Hematologic Toxicity

- Grading of chemotherapy induced decreases in blood counts, hemoglobulin, lymphocytes, neutrophils and platelets
- Occurs because of effects of treatment on bone marrow
- Areas covered in hematologic toxicities are
    - Anemia
    - Febrile neutropenia
    - Disseminated intravascular coagulation (DIC)
    - Hemolysis
    - Spleen disorder
    - Hemolytic uremic syndrome

Anemia

- Treatment is the most common cause of anemia in cancer patients
- Consequences of anemia
    - Impaired functional status
    - Diminished physiologic reserve
    - Fatigue that can be disabling
- Three main factors contribute to anemia in any patient
    - Red blood cell (RBC) loss
    - Increased RBC destruction
    - Decreased RBC production

Considerations

- Is the anemia a direct effect of the malignancy itself
    - Internal or external bleeding
    - Impaired absorption of nutrients
- Is anemia an effect of the product of malignancy
    - Hemolysis, thrombotic thrombocytopenic purpura, (TTP), disseminated intravascular coagulation (DIC)
- Is anemia an effect of the treatment
    - Chemotherapy
    - Radiation therapy

Nursing Considerations: Assessment

- Patient medical history
- Treatments and medications
- Signs and symptoms
- Diagnostic tests
    - Labs
        - Complete blood count
        - Chemistry panel
- Educate patient on signs and symptoms of anemia
    - Give patient symptoms guidelines that they should alert nurse or physician

Management

- Remove the malignancy
- Transfuse packed red blood cells (PRBC's) as indicated
- Administer recombinant erythropoietin stimulating agents (ESA)

Erythropoietin Stimulating Agents

- Information surrounding the administration of ESAs
  - The presence of anemia has been linked to an adverse prognosis
  - ESA use in patients with cancer has become controversial because of data linking ESA use to an excess of thromboembolic events, inferior survival, and worse cancer outcomes
  - There is general agreement that ESAs are not indicated in anemic cancer patients who are not receiving chemotherapy
  - Whether ESAs should be avoided in patients who are receiving myelosuppressive chemotherapy with the intent of cure remains controversial

Thrombocytopenia

- A decrease in circulating platelets below 100,000/mm^3
- Normal platelet count is 150,000-400,000/mm^3
- Major function of platelets is to prevent blood loss by initiating clot forming mechanisms

Nursing Considerations

- Monitor platelet counts
- Implement thrombocytopenic precautions
- Educate patient and family members on precautions and recognize signs and symptoms of bleeding

Management

- Transfuse as necessary
- Assess patient for signs and symptoms of bleeding

Neutropenia

- An abnormal decrease in the number of neutrophils in the blood
- Neutropenia lasting longer than 7 days and an absolute neutrophil count < 500 increase the patient's risk of infection

Nursing Considerations

- Monitor neutrophil count daily
- Implement neutropenic precautions
- Educate patient and caregiver of signs and symptoms of infection and neutropenic precautions

Cardiac Toxicity

- An alteration in cardiac function related to cancer treatment which includes
    - Heart failure
    - Right ventricle dysfunction
    - Left ventricle dysfunction
    - Hypotension
    - Hypertension
    - Sinus bradycardia
    - QTc interval prolongation

Risk Factors

- Pre-existing cardiac conditions
- Age
- Radiation to chest in the combination with cardio-toxic chemo
- Cumulative drug doses
- Receiving multiple cardio-toxic drugs
- Hematopoietic cell transplantation
- Host susceptibility
- Hepatic or renal dysfunction
- Smoking
- Diabetes

Toxicity

- Differ based on drug, dose, rate of infusion, overall treatment plan, and past treatments
- The most common drug class implicated in cardiac toxicity is the anthracycline class
    - Other common drugs and drug classes that can cause cardiac toxicity are;
        - 5-Fluorouracil (5-FU)
        - Cyclophosphamide and Ifosphamide
        - Taxanes
        - Cisplatin, mitomycin, and busulfan
        - Trastuzumab, lapatinib, sunitinib, sorafenib, rituximab, imatinib, bevacizumab
        - IL-2 and arsenic trioxide

Cardiac Toxicity of Anthracycline

- Class of drug most commonly implicated in cardiotoxity
- The toxicities can be divided into acute and chronic
- The chronic toxicities are mostly linked to a cumulative dose of anthracyclines
- Attempts at altered dose schedules and administration of Totect and Zinecard (dexrazoxane) have not reduced cardiac toxicity

Cardiac Toxicity: Acute vs. Chronic

Acute
- EKG changes
- Arrhythmias
- Heart block
- Ventricular dysfunction
- An increase in plasma brain natriuretic peptide
- Ischemia
- Vasospasms

Chronic
- Cardiomyopathy
- Congestive heart failure
- Low voltage QRS

Anthracyclines Acute Toxicity
- Less common occurring
- Most resolved within one week of occurrence, not life threatening
- Cardiac monitoring is not typically recommended for patients with normal cardiac functions

Management
- Baseline EKG
- Cardiac enzymes
- Correct electrolyte imbalances
- Treat arrhythmia with medication

Anthracycline Chronic Toxicity
- Adults usually present within a year of therapy
- Survival has improved due to more aggressive medical management, including medications such as ACE inhibitors and beta blockers
- In childhood cancer survivors treated with anthracycline many have cardiac dysfunctions

Cardiotoxicity: Doxorubicin Cumulative Dose
- Recommended not to exceed 400-550 mg/m2 in adults

Nursing Considerations
- Thorough history and physical including any pre-existing cardiac conditions
- Monitor cardiac functions throughout treatment and after
- Keep track of cumulative dose of anthracyclines
- Educate patient on importance of informing medical team if any symptoms arise

GI Toxicity/Mucositis: Nausea and Vomiting

- Acute nausea: Occurs within first 24 hours of treatment usually at 1-2 hours
- Delayed nausea: Occurs more than 24 hours after treatment
- Vomiting categorized by number of times vomited in a day and time period between those times
- Anticipatory nausea: Occurs as a conditioned response from previous chemo treatments
    - May occur before during or after treatment
- Breakthrough nausea and vomiting: Nausea and vomiting that occurs within 5 days of prophylactic use of antiemetic's and requires treatment
- Refractory nausea and vomiting: Nausea and vomiting that does not respond to treatment

Medications for Nausea

Major Neurotransmitter Targets	Medication Class	Drugs
Serotonin	5HT3 antagonists	Ondansetron and granisetron
Neurokinin	NK-1 antagonists	Aprepitant
Dopamine	D-2 antagonists	Prochlorperazine
Histamine	H-1 antagonist	Promethazine
Acetylcholine	Muscarinic	Scopolamine
Cannabinoid	Cannabinoid agonist	Dronabinol

Nausea Medications Adverse Events and Nursing Implications

Medication/Drug Classification	Adverse Event	Nursing Implementation
Ondansetron/ Serotonin agnostic	• Headache, fever • Diarrhea, constipation • Transient increase in serum AST/GPT	• Assess for headache and fever, may give Tylenol if indicated • Assess number and consistency of stools • Monitor liver functions
Granisetron/ Serotonin agnostic	• Headache • Constipation	• Assess for headache and severity of headache • Assess for bowel regularity
Palonosetron/Serotonin agnostic	• Headache • Constipation	• Assess for headache and severity • Assess for bowel regularity •

_____
_____
_____
_____
_____

Aprepitant/ NK-1 antagonist	• Constipation or diarrhea • Hiccups • Tiredness	• Assess bowel regularity • Assess level of sedation • Avoid alcohol and CNS depressants • Avoid tasks that require alertness
Prochlorperazine /D-2 antagonist	• Sedation • Blurred vision • Orthostatic hypotension • Dry mouth	• Avoid alcohol and other CNS depressants • Avoid tasks that require alertness • Assess vision and impact on safety • Monitor patient for orthostatic changes • Educate patient to rise slowly from lying or sitting position • Suck on ice chips or hard candy • Frequent intake of fluids
Promethazine/ H-1 antagonist	• Sedation • Hypotension • Dry mouth • Urine retention	• Monitor level of consciousness • Monitor vital signs • Suck on ice chips or hard candy • Drink plenty of fluids • Monitor intake and output
Lorazepam/ Benzodiazepine	• Sedation • Dizziness • Weakness • Anterograde amnesia	• Assess level of conscious • Assess memory

Nursing Considerations

- Assess patient's nausea and vomiting
- Administer medication as per order
- Non-pharmacologic interventions
    - Meditation
    - Warm/cold compress
    - Music

Mucositis

- Mucositis is an inflammatory process that affects the mucous membranes of the oral cavity and gastrointestinal tract
- Estimated to occur in about 40% of patients secondary to chemotherapy and almost 100% of those receiving radiation for head and neck cancer
- Approximately 80% of those undergoing hematopoietic stem cell transplantation will experience some level of oral mucositis

_____
_____
_____
_____
_____

Treatment of Specific Risk Factors

- Age
- Poor oral health and hygiene
- Reduced salivary secretion
- Genetic factors
- Low body mass index
- Decreased renal function
- Tobacco use
- Previous cancer treatment with chemo or radiation
- Poor nutritional status
- Higher levels of oral microflora
- Inflammation

Radiation Therapy

- Increased risks for those patients with primary cancers of the oral cavity, oropharynx, or nasopharynx.
- Radiation treatment with > 5,000 Gray
- Those treated with more than one radiation treatment a day

Chemotherapy

- Antimetabolites such as 5FU, and MTX
- Alkylating agents such as melphalan, and busulfan
- Antitumor agents such as dactinomycin, doxorubicin, and epirubicin
- Taxanes such as docetaxel and paclitaxel

Nursing Considerations

- Manage pain
- Rinse mouth four times a day after meals with bland solutions such as normal saline
- Water based moisturizers to protect lips
- Educate patient on proper oral hygiene
- Educate patient to avoid tobacco, and alcohol

Hepatic Toxicity

- Occurs when drug metabolites cause damage and inflammation to liver cells or blood flow to liver is occluded
- Inhibits livers ability to metabolize drugs
- Leads to fatty changes, necrosis, and fibrosis

Clinical Manifestations

- Insidious
- Can range from asymptomatic with abnormal lab values to an acute illness resembling viral hepatitis
- Distinguishing between drug induced hepatotoxicity and other causes of liver injury can be difficult
- An abdominal ultrasound could assist in determining cause

Hepatitis

- Jaundice, anorexia, fever, right upper-quadrant (RUQ)/epigastric abdominal pain, abdominal distension due to ascites

Portal Hypertension

- Often asymptomatic until a problem develops

Splenomegaly

- Abdominal wall collateral vessels and thrombocytopenia

Liver Failure

- Fatigue/malaise, lethargy, anorexia, N/V, RUQ pain, pruritus, jaundice, abdominal distension, and subtle mental status changes
- As liver failure develops the symptoms usually become more severe, including hepatic encephalopathy, confusion, or eventually comatose

Management: Hepatic Toxicity

- Some agents cause reversible toxicity while others are associated with a progressive course that can lead to fibrosis or cirrhosis
- Toxicity will generally recur upon reintroduction of the offending substance if the reaction was immunologically based
- Patients with pre-existing liver disease should receive treatment for that disorder prior to starting chemotherapy to attempt to minimize the hepatotoxicity of the treatment
- Dose adjustments should occur appropriately based on pretreatment liver function

Management: Liver Failure/Hepatitis

- Managing patients with acute liver failure requires a thorough understanding of the complications that may develop
- Metabolic disturbances, encephalopathy, cerebral edema, seizures, and renal failure
- Correct electrolyte imbalances, decrease ammonia levels, monitor intracranial pressure and preserve renal function

Management: Portal Hypertension

- Manage the underlying cause
- Assess for the presence of esophageal varices, manage bleeding if it is occurring
- Assess for ascites, put patient on sodium restriction, utilize diuretics
- Dose reduce or discontinue medication

Management: Renal and Urinary Tract Toxicity

- Acute kidney injury
- Graded by creatinine level and whether or not dialysis is needed
- Hemorrhagic cystitis
- Proteinuria
    - Graded simply by the amount of protein present in the urine

Risk Factors

- Intravascular volume depletion due to external losses or fluid sequestration
- Concomitant use of other nephrotoxic drugs
- Radiographic ionic contrast media in patients with or without preexisting renal dysfunction
- Urinary tract obstruction secondary to tumor
- Intrinsic renal disease

Management and Treatment

- Prevention/risk reduction with the use of chemo-protectants such as mesna and amifostine
- Aggressive and adequate hydration
- Electrolyte monitoring
- Maintain hemodynamic status
- Urine alkalization
- Forced diuresis
- Monitor labs

Hemorrhagic Cystitis

- Monitor and measure hematuria
- Evaluate for signs and symptoms of urinary obstruction
- Encourage frequent bladder emptying
- Maintain aggressive hydration
- Utilize three-way Foley with irrigation if indicated

Pulmonary Toxicity

- Pulmonary edema and effusions
- Interstitial lung disease (ILD), pulmonary fibrosis, and pneumonitis
- Acute respiratory distress
- Respiratory infections
- Wheezing and bronchospasms

Risk Factors

- Radiation therapy to the chest
- Underlying pulmonary disease
- Multiple drugs that cause pulmonary toxicity
- Hepatic or renal impairment

Pneumonitis

- Inflammation of the lung caused by a chemical or immune mediated response
- Clinical Manifestations
    - Cough, dyspnea, fatigue, fever, pulmonary infiltrates

ILD

- Persistent pneumonitis
- Clinical Manifestations
    - Chronic dyspnea and cough
    - Progressive scarring of lungs leads to fibrosis

Fibrosis

- Loss of elasticity, hardening of lung tissue

Management

- Stop the drug, steroids, manage symptoms, supportive care

Neurological Toxicities

- Dysfunction of cranial nerves
    - Akathisia
    - Amnesia
    - Aphonia
    - Arachnoiditis
    - Ataxia
- Peripheral neuropathy
- Cognitive dysfunction
- Acute encephalopathy
- Ischemia cerebrovascular
- Extrapyramidal disorder
- Autonomic dysfunction
- Agitation
- Anxiety

Neurological: Risk Factors

- Drug dosage
- Radiation to the head
- Intrathecal administration
- Age
- Central Nervous System (CNS) depressants
- History of diabetes or chronic alcohol abuse
- Renal or hepatic dysfunction

Peripheral Neuropathy

- Sensory Clinical Manifestations:
    - Arthralgia, myalgia, paresthesia, sensory loss
- Motor Clinical Manifestations
    - Decrease or loss of deep tendon reflexes, foot drop, muscle weakness and atrophy

Management

- Assess severity and impact on patient's life
- Dose reduce or discontinue the drug
- Consult physical or occupational therapy
- Decrease pain and increase function
- Maintain safety

Ototoxicity

- Related to the cumulative dose effects of cisplatin
- Symptomatic hearing loss occurs in 15-20% of patients
    - Audiometric evidence of impaired hearing appears in 75% of patients
- Early detection of the ototoxicity by audiometry, may minimize the severity of the impairment of sounds recognized for speech

Acute Encephalopathy: Risk Factors

- Significant fluid overload, mean BP greater than 25% of baseline, creatinine greater than 1.8 mg/dL
- Associated with reversible abnormalities in the white matter of the occipital, parietal, and frontal lobes

Clinical Manifestations

- Altered mental status
- Behavioral changes
- Confusion
- Cognitive dysfunction
- Lethargy
- Seizures
- Somnolence
- Hypertension

Diagnosis

- Confirmed by brain MRI and distinct changes in white matter

Treatment

- Stop or dose reduce the offending agent, manage hypertension, seizure prophylaxis

Cognitive Dysfunction

Effects
- Language
- Memory
- Concentration
- Attention
- Multitasking
- Coping
- Performance
- Emotions

Multifactorial Causes
- Cancer
- Changes in hormones
- Side effects
    - Anemia
    - Fatigue
    - Insomnia
    - Neurologic irritation/dysfunction
- Emotions
    - Anxiety
    - Depression
    - Fear

Risk Factors
- Women
- High dose regimens

Treatments
- Assess and manage causative factors
- Orient frequently with calendars and clocks
- Ensure patient safety
- Educate the patient, family members and caregivers

Immunotherapy Goal
- Augment the immune system to create an anti-tumor T cell response

Mechanism of Action
- Increase activity of T-cells
- Decrease the activity of T-cell suppressors

FDA Approved Novel Immunotherapies

- Bi-Specific T-cell engager antibodies (BiTEs)
- CTLA4 checkpoint inhibitor
- Chimeric antigen receptor (CAR) T-Cells
- Dendritic cell vaccines
- Oncolytic viruses
- PD-1 checkpoint inhibitors
- PD-L1 checkpoint inhibitor
- Peptide vaccines
- T cell clones
- Tumor infiltrating lymphocytes (TIL)

Toxicity

- Result from stimulation of the immune system by the drug
- Hyper proliferation of lymphocytes and cytokine release
- Can range from mild to severe specific syndromes to severe organ dysfunction

Immune System Toxicities

- Allergic reaction
- Anaphylaxis
- Autoimmune disorder
- Cytokine release syndrome

Adverse Effects

- Related to increased T-cell activity
- More common in CTLA4 checkpoint inhibitors
- Immune response adverse events (irAEs)
    - Cutaneous/mucosal irritation
    - Diarrhea/colitis
    - Hepatotoxicity
    - Pneumonitis
    - Endocrinopathies

Vascular Toxicities

- Flushing
- Hematoma
- Hot flashes
- Hypertension
- Hypotension
- Lymphedema
- Phlebitis
- Capillary leak syndrome

Capillary Leak Syndrome

- A toxicity in which intravascular fluids leak into the tissue space causing generalized edema and can lead to organ failure

Other Adverse Event Reporting Systems

- PRO-CTCAE: Patient reported outcomes consider the patient's perspective on adverse events
    - Not yet in widespread use
- Reports that compared CTCAE and PRO ratings using various PRO measures of adverse events found fair to moderate agreement between the two systems, with large variations in many of the studies
- Radiation Therapy Oncology Group (RTOG): For some toxicities related to radiation therapy
- World Health Organization (WHO) Adverse Drug Reaction Terminology (WHO-ART): International drug monitoring

Homework

Use the following regimen to complete the following case study information. The answers will be reviewed and discussed during the Review session.
Hyper-CVAD/MTX-Ara-C

Course 1:

- Cyclophosphamide 300mg/m2 IV over 3 hours every 12 hours for 6 doses on day 1 (8/1/17), day 2 (8/2/17), and day 3 (8/3/17). Start first dose at 8am.
- Doxorubicin 50mg/m2 IV over 48 hours on day 4 (8/4/17) at 8am.
- Vincristine 2mg IV over 15 minutes on day 4 (8/4/17) at 8am. Repeat on day 11 (8-11-17) at 8am.
- Dexamethasone 40mg/day IV on day 1 (8/1/17), day 2 (8/2/17), day 3 (8/3/17) and day 4 (8/4/17) and day 11 (8/11/17), day 12 (8/12/17), day 13 (8/13/17), and day 14 (8/14/17)
- Administer 30 minutes prior to chemotherapy
- Filgrastim 5mcg/Kg sq daily until ANC > 500. Start day 8 (8/8/17) at 8am.

Course 2**:**

- Methotrexate (MTX) 200mg/m2 over 2 hours IV on day 1 (9/5/17) at 8am
- MTX 800mg/m2 over 22 IV hours on day 1 (9/5/17) at 10am
- Cytarabine 3,000mg/m2 IV over two hours every 12 hours for 4 doses on day 2 (9/6/17), and day 3 (9/7/17): First dose at 8am
- Leucovorin 50mg IV every 6 hours until MTX level <50nM: Start day 2 (9/6/17) at 8pm
- Filgrastim 5mcg/Kg SQ daily until ANC > 500: Start on day 4 (9/8/17) at 8 pm

1. Calculate the doses for all medications using actual body weight
    - BT is 6 ft 3 in tall and weighs 270 pounds
    - SA is 5 ft 1 inch tall and weighs 90 pounds

	BT dose	SA dose
Course 1:		
Cyclophosphamide 300mg/m2		
Doxorubicin 50mg/m2		
Vincristine 2mg		
Filgrastim 5mcg/Kg		
Course 2:		
Methotrexate Bolus 200mg/m2		
Methotrexate Infusion 800mg/m2		
Cytarabine 3,000mg/m2		
Filgrastim 5mcg/Kg		

2. For each chemotherapeutic agent in the regimen list:
    - 2 pretreatment physical assessments
    - 2 labs, diagnostic studies
    - 1 indication dose reduce or hold the dose
    - 2 components of patient/ family education for each agent

	2 Physical Assessments	Labs and/or Diagnostic Studies	Variables to Reduce or Hold Dose	2 Patient/ Family Education Aspects
Course 1				
Cyclophosphamide				
Doxorubicin				
Vincristine				

_____
_____
_____
_____
_____

	Physical Assessments	Labs and/or Diagnostic Studies	Variables to Reduce or Hold Dose	Patient/ Family Education
Course 2				
Methotrexate				
Cytarabine				
Leucovorin				

3. List 2 co-morbid conditions may impact the patient's ability to receive full doses of each of these agents or at least require closer monitoring?

    1.

    2.

_____
_____
_____
_____
_____

4. On the attached calendars write in the schedule, including start times, for all agents.

Course 1

August 2017						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

Course 2

September 2017						
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

Case Study

JK is a 62 y/o female who noted a nodule in her breast 4 weeks ago. Work-up revealed breast cancer with the sentinel lymph node dissection positive for malignant cells. The plan is to begin chemotherapy at this time. She is now presenting to you for her first dose of chemo. You obtain the following information:

Weight: 122 kg Height: 5'5" BP: 160 / 98 P: 68 RR: 20 T: 37.4 C

Lab Test	JK's Lab Values	Reference Range
CBC		
WBC	5. 5 x 103/cu mm	(4.3 - 10.8 x 103/cu mm)
Differential:		
• Basophils		0 %
• Eosinophils		0 %
• Lymphocytes	40 %	(20 - 40%)
• Monocytes		3 %
• Neutrophils:		
○ Bands	2%	(0%)
○ Segmented	55%	(40 - 60%)
• Platelets	250 K	(200 -400K)
• Hgb	12 gm/dl	(13 - 18 gm/dl)
• Hct	35%	(37 - 48%)
Chemistry		
Na+	140 mEq/L	(135 - 145)
K+	3.5 mEq/L	(3.5 - 5.0)
Cl-	100 mEq/L	(95 - 106)
Phos	3.8 mg/dl	(3.0 - 4.5)
Glucose	106 mg/dl	(70 - 110)
BUN	10 mg/dl	(8 - 25)
Cr	0.8 mg/dl	(0.6 - 1.5)
Mg	1.7 mEq/L	(1.5 - 2.0)

Calculate JK's ANC

$$\text{ANC} = \frac{(\%\ \text{neutrophils} + \%\ \text{bands})}{100} \times \text{WBC}$$

Show your work:

The physician orders paclitaxel (Taxol) 135mg/m2 and carboplatin (Paraplatin) with an AUC 4. The physician calculates JK's drug doses at:

- paclitaxel (Taxol): 330 mg
- carboplatin (Paraplatin): 660 mg

The physician hands you JK's orders to check. You must calculate JK's drug doses for paclitaxel and carboplatin. Calculate JK's BSA:

Formulas

Weight Conversion Formula	Pounds = Kg x 2.2	Kilograms = lbs ÷ 2.2
Height Conversion Formula	Inches = cm ÷ 2.54	Centimeters = in x 2.54
BSA (m2) =	$\frac{\text{height (in) x weight (lbs)}}{3131}$	$\frac{\text{height (cm) x weight (Kg)}}{3600}$

Calculate JK's paclitaxel dose:

Drug dose = ordered dose x BSA

Show your work:

You determine that your dose is not the same as the dose the physician ordered. You must follow the 10% rule to determine if the written dose (dose calculated by the physician) is safe to administer. Calculate the 10% rule:

Formulas

Method 1	Method 2
	10% = your dose x 0.1
Upper Limit = your dose x 1.10	Upper Limit = your dose + 10%
Lower Limit = your dose x 0.90	Lower limit = your dose – 10%
	10% = your dose x 0.1

Show your work

The safe administration range is _____ mg - _____ mg.

Is the physician's dose safe to administer (circle your answer) Yes No

_____
_____
_____
_____
_____

Calculate JK's carboplatin dose:

$$\text{Female CrCl} = \left(\frac{(140 - \text{age}) \times \text{Weight in Kilograms}}{72 \times \text{Serum Creatinine}} \right) \times 0.85$$

Calvert Formula: Dose in mg = AUC x (CrCl + 25)

Show your work

What would JK's carboplatin dose be if she were a male? _____

Appendix A

Antineoplastic Therapy Formulas

Metric to English Conversions

1 kg = 2.2 lbs

1 inch = 2.54 centimeters

BSA

$$\text{BSA } (m^2) = \text{metric units} \quad \sqrt{\frac{\text{height (cm)} \times \text{weight (Kg)}}{3600}}$$

$$\text{BSA } (m^2) = \text{English units} \quad \sqrt{\frac{\text{(inches)} \times \text{weight (lbs)}}{3131}}$$

ANC

$$\text{ANC} = \frac{\text{(\% neutrophils + \% bands)}}{100} \text{ X total WBC}$$

Creatinine Clearance Formula

$$\frac{(140 - \text{age}) \times \text{Weight in Kilograms}}{72 \times \text{Serum Creatinine}} = \text{CrCl males}$$

$$\left(\frac{(140 - \text{age}) \times \text{Weight in Kilograms}}{72 \times \text{Serum Creatinine}}\right) \times 0.85 = \text{CrCl females}$$

Calvert Formula

Dose in mg = AUC x (CrCl + 25)

Appendix B

Oncology Drug Handling Precautions

National Institute for Occupational Safety and Health (NIOSH)

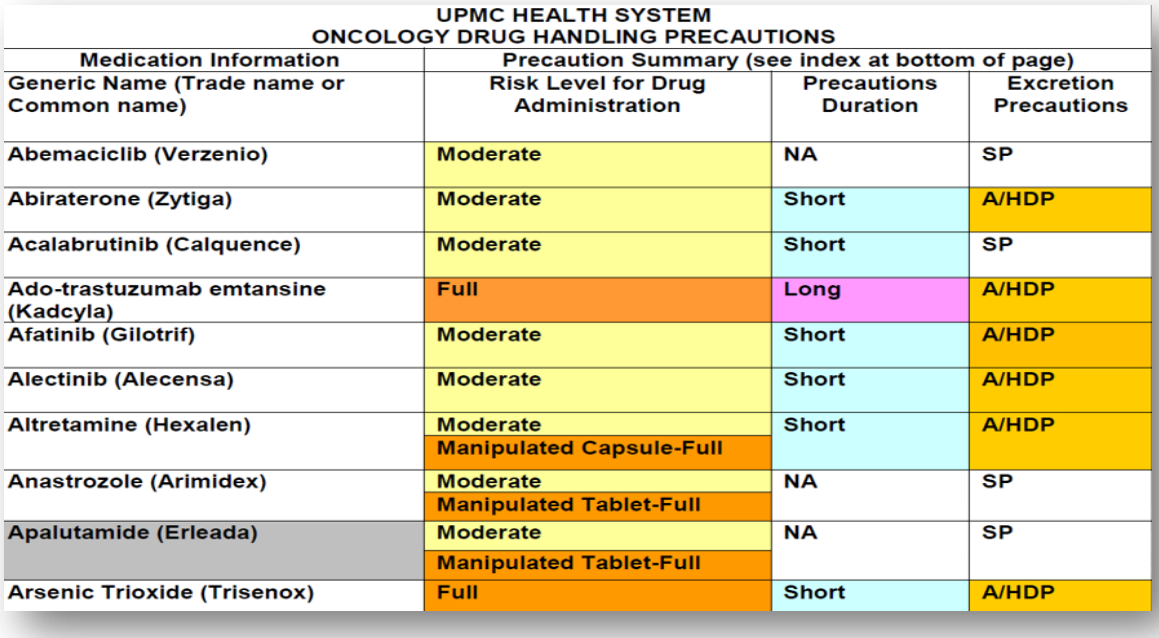
- Through the Centers for Disease Control and Prevention (CDC)
- Hazardous drug exposures in healthcare
    - Important in Oncology due to risk of exposure to hazardous drugs
    - Antineoplastic agents

Oncology Drug Handling Precautions

- UPMC employees can access the list of oncology drug handling precautions through the Infonet

Access Infonet

- https://infonet.upmc.com/Pages/default.aspx
- Search
    - In the search bar type in; NIOSH list, drug excretion list, antineoplastic excretion, oncology drug handling precautions list and click search
    - Document selection
    - Click on the document titled Oncology Drug Handling Precautions List
    - Drug handling list



UPMC HEALTH SYSTEM
ONCOLOGY DRUG HANDLING PRECAUTIONS

Medication Information	Precaution Summary (see index at bottom of page)		
Generic Name (Trade name or Common name)	Risk Level for Drug Administration	Precautions Duration	Excretion Precautions
Abemaciclib (Verzenio)	Moderate	NA	SP
Abiraterone (Zytiga)	Moderate	Short	A/HDP
Acalabrutinib (Calquence)	Moderate	Short	SP
Ado-trastuzumab emtansine (Kadcyla)	Full	Long	A/HDP
Afatinib (Gilotrif)	Moderate	Short	A/HDP
Alectinib (Alecensa)	Moderate	Short	A/HDP
Altretamine (Hexalen)	Moderate Manipulated Capsule-Full	Short	A/HDP
Anastrozole (Arimidex)	Moderate Manipulated Tablet-Full	NA	SP
Apalutamide (Erleada)	Moderate Manipulated Tablet-Full	NA	SP
Arsenic Trioxide (Trisenox)	Full	Short	A/HDP