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Air transportation over-utilization in pediatric trauma patients☆

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A B S T R A C T

Background: Air transportation can be a life-saving transfer modality for trauma patients. However, it is also costly and carries risk for air-crews and patients. We sought to examine the incidence of air transportation among pediatric trauma patients as well as the rate of over-triage in utilizing this intervention.
Methods: We conducted a single-institution retrospective review of all pediatric trauma patients who utilized air transportation, either from scene to hospital or hospital to hospital Emergency Department (ED) transfers, between 2013 and 2018.
Results: There were 348 pediatric trauma patients who utilized air transport. More than half of all patients ($n = 186$, 55.9%) were discharged from the hospital within 48 h, 121 (36.3%) were discharged within 24 h, and 34 (10.2%) were discharged home from the ED. The mean ISS was 11.2 ± 0.5 while only 31% had an ISS ≥15. There were 97 patients (27.9%) with elevated age adjusted shock index, and 101 patients (29.0%) who required time sensitive interventions.
More than half of patients (59.3%) were initially taken to an outside hospital (OSH) and were then transferred to our facility by air while 40.4% were transported directly from scene to our institution by air. Patients who were transferred from an OSH were younger (6.8 ± 0.4 vs 11.2 ± 0.4, $p < 0.01$) and had a higher incidence of an elevated age-adjusted shock index (32.4% vs 19.1%, $p = 0.006$) as well as mortality (6.3% vs 1.4%, $p = 0.03$). However, ultimately there were no differences in ISS, rates of operative intervention, PICU utilization, or time sensitive intervention. Both groups had similarly high rates of discharge within 48 h, 24 h, and from the ED.
Conclusions: Air transportation among pediatric trauma patients from scene to hospital and hospital to hospital is over-utilized based on multiple metrics including low rates of ISS ≥15, elevated age-adjusted shock indexes, low rates of time sensitive intervention, as well as high rates of discharge within 24 and 48 h.
Level of Evidence: III
Type of Study: Clinical Research-retrospective review.

Air transportation can be a life-saving intervention, particularly in pediatric trauma patients [1]. Patients may be transported from scene to hospital or from a smaller hospital to a Level-1 Trauma center by air significantly faster than by ground. This is particularly salient for patients who do not live within a reasonable driving distance to a hospital, much-less a pediatric trauma center. However, air transportation is also costly, and there are risks associated with air travel, particularly in poor weather and at night.

Traditionally, transportation by air has been restricted to those who would benefit from more expeditious transport times [2–4]. However, literature has consistently reported high rates of overtriage in trauma patients who have utilized air transportation. An analysis of the National Trauma Databank (NTDB) found that nearly 40% of pediatric trauma patients transported by helicopter had only minor injuries [5]. Another NTDB study found that 28% of patients transported by helicopter were discharged within 24 h [6]. A retrospective review at a Level-1 Trauma center found that 23% of children who were transported by helicopter were discharged home from the ED. [7]

We sought to evaluate our own institutional experience with overtriage in pediatric trauma patients who utilized air transportation. We hypothesize that a significant number of pediatric trauma patients who utilize air transportation prior to presentation to our institution do not have a clinical indication and do not demonstrate a clear benefit from the faster transportation time.

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1. Methods

We conducted a 6-year retrospective review of all pediatric patients (aged ≤18 years) who utilized air transportation (helicopter or fixed wing) prior to presentation to our institution for trauma evaluation from 2013 to 2018 (IRB# 00000828). The study was conducted at Children's Mercy Hospital (CMH), located in Kansas City, Missouri. CMH is the only Level-1 pediatric trauma center in the region, serving both an urban and rural population with a catchment of 300 miles including Western Missouri and Eastern Kansas.

Trauma patients who were initially evaluated at our Emergency Department (ED) but were then transferred to another institution for further management, or who were initially evaluated and admitted to an Outside Hospital (OSH) and then transferred to our institution's inpatient service were excluded from this study.

The electronic medical records and trauma registry were reviewed for each patient. Data abstracted included patient demographics, initial CMH ED vital signs, location of scene of injury and OSH, transport times, time spent at the OSH, injuries, procedures, length of stay (LOS), and outcomes. We used age-adjusted shock index (SIPA) as a surrogate measure of hemodynamic instability, using initial vital signs upon presentation to the CMH trauma bay [8]. Patients were classified as having a time sensitive intervention if the patient was intubated, hemodynamically unstable, or required a life/limb saving surgery or procedure, as described by Meyer et al. [9]

All data were collected retrospectively and analyzed using standard statistical methods. Continuous variables were calculated as mean ± standard error (SE). The statistical significance of continuous variables were calculated by independent samples Student's *t*-test. (Table 2) Categorical variables were analyzed using chi-square statistics. (Table 2) p-Values <0.05 were considered statistically significant.

2. Results

There were a total of 348 pediatric trauma patients who utilized air transportation prior to presentation to our facility. A majority of these patients (n = 207, 59.3%) initially presented to an OSH and were then transferred to our ED via air. (Fig. 1) Of these patients, 103 presented via private vehicle (49.8%) while 82 patients (39.6%) presented via ground ambulance. Another 141 patients (40.4%) were transported directly from the scene to our ED. More than half of all patients (n = 186, 55.9%) were discharged from the hospital within 48 h, 121 (36.3%) were discharged within 24 h, and 34 (10.2%) were discharged home from the ED.

Table 1
Demographics and outcomes of trauma patients who utilized air transport.

Average age (years ± SE)	8.6 ± 0.3
Male, n (%)	228 (65.5%)
Mechanism, n (%)	
Blunt	305 (87.6%)
Penetrating	21 (6.0%)
Burn	19 (5.5%)
ISS ± SE	11.2 ± 0.5
Elevated SIPA, n (%)	97 (27.9%)
Time-sensitive intervention, n (%)	101 (29.0%)
Operative intervention, n (%)	141 (40.5%)
PICU utilization, n (%)	133 (38.2%)
Mortality, n (%)	15 (4.3%)

We then reviewed the clinical status of these patients to determine if the patient required a time sensitive intervention. (Table 1) There were only 101 patients (29.0%) who met criteria. There were 97 (27.9%) patients with elevated SIPA upon presentation. The mean ISS was 11.2 ± 0.5 with only 31% of patients with an ISS ≥15. The rate of operative intervention was 40.5%, while 38.2% were admitted to the pediatric intensive care unit (PICU). Overall mortality was 4.3%.

The patients were then divided between those who were transported directly from scene to our facility and those who were initially taken to an OSH and then transferred to our facility via air for subgroup analysis.(Table 2) Patients who were transferred from an OSH were younger (6.8 ± 0.4 vs 11.2 ± 0.4, p < 0.01), and also were closer to the OSH than CMH from scene (17.4 ± 2.8 vs 62.5 ± 2.8 miles, p < 0.01). There were no differences in scene time or transport time to the initial receiving facility.

There were also no differences in ISS, percentage of patients with an ISS ≥15, rates of operative intervention, PICU utilization, or time sensitive interventions required between the two groups. Similarly, there were no differences in early discharge rates in patients who transferred from an OSH vs. directly from the scene. However, more patients who were transferred from an OSH had an elevated SIPA (n = 67, 32.4%, vs n = 27, 19.1%, p = 0.006) as well as an associated increased mortality (n = 13, 6.3%, vs n = 2, 1.4%, p = 0.03). (Table 2).

Our institution's Pediatric Critical Care Air Crew transported 30.7% of all patients and 51.7% of patients transferred from an OSH. The average distance from OSH to CMH was 113.0 ± 3.8 miles with an average interfacility transport time of 41.1 ± 1.9 min. The average time spent at the OSH prior to transfer was 208.0 ± 27.6 min.

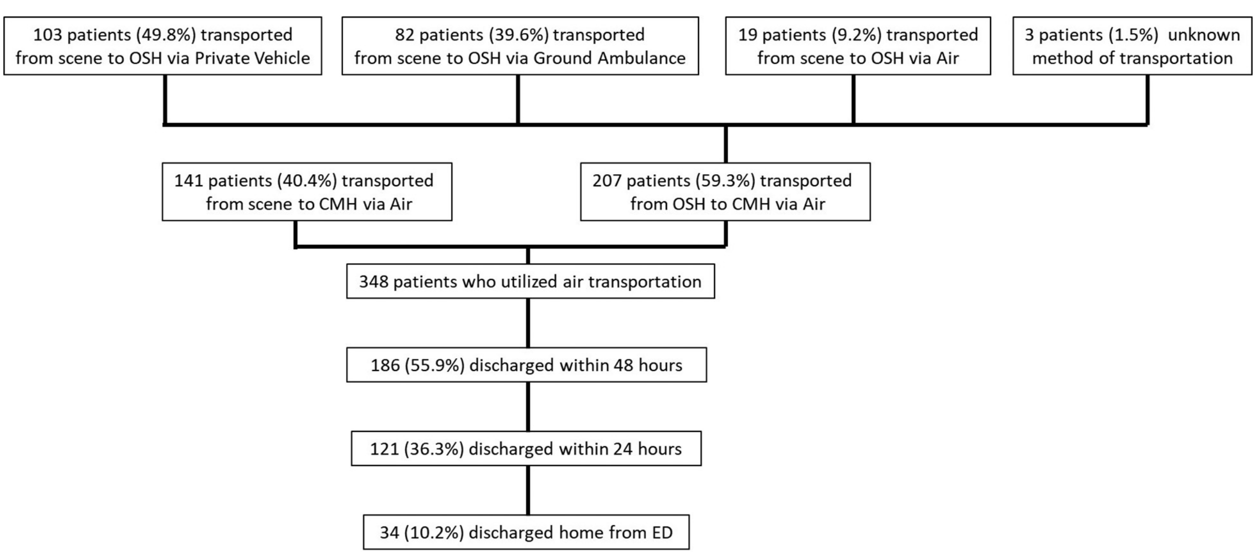

Fig. 1. Patient utilization of air transportation and outcomes.

Table 2
Transfers from outside hospitals (OSH) and direct from scene.

	Txf from OSH to CMH	Scene to CMH direct	p-Value
Average age (years ± SE)	6.8 ± 0.4	11.2 ± 0.4	***<0.001***
Male, n (%)	137 (66.2%)	91 (64.5%)	0.8
Mechanism, n (%)			0.2
Blunt	178 (86.0%)	127 (90.1%)	
Penetrating	12 (5.8%)	9 (6.4%)	
Burn	16 (7.7%)	3 (2.1%)	
Distance from scene to OSH/CMH (miles ± SE)	17.4 ± 2.8	62.5 ± 2.8*	***<0.001***
Scene time (min ± SE)	16.2 ± 2.3	15 ± 0.7	0.7
Transport time from scene to OSH/CMH (min ± SE)	21.8 ± 3.5	27.2 ± 1.3	0.09
ISS ± SE	10.9 ± 0.6	11.7 ± 0.8	0.4
Elevated SIPA, n(%)	70 (33.8%)	27 (19.1%)	***0.006***
Time sensitive intervention, n(%)	62 (30.0%)	39 (27.7%)	0.64
Operative intervention, n (%)	81 (39.1%)	60 (42.6%)	0.5
PICU utilization, n (%)	80 (38.6%)	53 (37.6%)	0.8
Mortality, n(%)	13 (6.3%)	2 (1.4%)	***0.03***
Discharged within 48 h, n(%)	110 (56.7%)	76 (55.1%)	0.9
Discharged within 24 h, n(%)	77 (40.0%)	44 (31.9%)	0.2
Discharged from ED, n(%)	24 (12.4%)	10 (7.3%)	0.2

3. Discussion

We present our cohort of pediatric trauma patients who have been transported to our ED via air. By multiple measures, the majority of these patients were overtriaged.

Fahy et al. defined overtriage as ISS <15 and determined an overall over-triage rate of 45% of all air transported pediatric patients. Of these patients, 32% were discharged within 24 h with 3% discharged from ED. [10] In contrast, our overall reported overtriage rate based on ISS <15 was 69% with 36.3% discharged within 24 h and 10.2% discharged directly from the ED. Meyer et al. examined pediatric trauma patients who underwent interfacility air transportation and reported that only 43% required time sensitive intervention [9]. We report 29% of patients required time sensitive intervention. Similarly, we tried to use SIPA as another surrogate for appropriate triage. Using this metric, only 27.9% of all patients met criteria for an elevated SIPA.

Overall, we had approximately a 70% overtriage rate based on ISS, need for time sensitive intervention, or SIPA. In comparison, the American College of Surgeons Committee on Trauma has described an overtriage rate of 30–50% as acceptable [11]. Not only is overtriage with regards to air transport costly, it also increases risk associated with air transport as well as unnecessary resource utilization [12].

We also separated patients who were directly transported to our ED as well as those who were initially taken to another hospital and then transferred by air as interfacility transport. Both groups had relatively equal rates of overtriage based on early discharge rates, ISS, and rate of time sensitive intervention. Patients from an OSH were younger and did have higher rates of elevated SIPA and mortality than those who were taken directly from scene to our ED. This may suggest that there may have been a population within those taken to an OSH who may have benefited from direct air transfer from scene to our institution, as the area's only Level-1 pediatric trauma center. However, the overtriage rate of this group was still high at 68.6% based on SIPA. Additionally, there did not appear to be any difference in rates of time sensitive intervention or early discharge rate.

As previously mentioned, overtriage of pediatric patients is not new [6,7,9,13,14]. As described by Engbrecth et al., there remains a disparity between perceived need for rapid transport and need for urgent intervention [14]. To combat this trend of over-triage, studies have attempted to identify those who may actually have a survival benefit and established criteria for air transportation. Polites et al. showed that a survival benefit with air transportation only occurs in pediatric patients with an Injury Severity Score (ISS) >15 [15], while another defined clear guidelines for helicopter transfer in patients with significant traumatic brain injury [16].

At our facility, the decision to transport by air has already been made by the referring facility or by our transport team, which is coordinated by a Pediatric Intensivist. Typically, our trauma team does not have any input in the mode of transportation. A potential target for intervention is the creation of an institutional protocol used by the accepting physician with criteria for air transportation from outside hospitals that would consider not only the clinical status and injuries of the child, but also the distance and capabilities of the referring facility. However, a limitation of such a protocol is that while we may decrease overtriage by our own transportation team, our air crew only transported 30.7% of all trauma patients who utilized air transportation. We do not have any authority or oversite of other air ambulance companies, particularly those who are private and/or for-profit.

There are additional reasons why air transportation may be warranted if not from clinical indication. If there are limited ground EMS crews in a remote region, sending a patient by ground EMS may place even greater strain on local resources than if sent by air transport. Additionally, other institutions and providers may be uncomfortable caring for pediatric patients and view air transport as the fastest way to appropriate care.

But these benefits continue to need to be weighed against the costs of air transportation. While our institution has a hospital-based air crew, most air transports are done by private air ambulance crews. As such, there is no centralized body to regulate air transport utilization. The number of air ambulance crews has doubled since 2002 when Medicare implemented a prospective fee schedule for air ambulance services and the majority emerged as for-profit providers [17]. Many patients find themselves utilizing an out-of-network, non-hospital based air ambulance provider and are left with a median balance of $15,172 [18]. Missouri billed $25.7 million for air ambulance services in 2017 alone, of which patients were responsible for $12.4 million after coinsurance, copays, and deductibles [19]. Additionally, some air ambulances advertise and offer memberships, particularly targeting rural areas that are remote from hospitals [20]. Furthermore, parents are often not allowed to accompany children in air transport, which may lead to significant periods of separation and place further emotional strain on both patient and families. This is particularly relevant for children with minor injuries and who are ultimately discharged from the emergency department after air transport.

Our data also demonstrates that patients spent an average of more than 3.5 h at an OSH prior to air transfer. Faster time to transfer (i.e. less time spent at the OSH prior to transfer) may also be beneficial as a means to faster evaluation by a pediatric trauma center as opposed to relying solely upon faster modes of transportation. This may also be relevant for those with elevated SIPA and/or those ultimately died, which was higher in the OSH transfer cohort.

One of the limitations of this study is its descriptive and retrospective nature. As such, while we may speculate, we may not be able to clearly delineate the reasons why air was chosen as the mode of transportation. Additionally, our SIPA values were calculated based on the first set of vital signs taken in our CMH trauma bay. The reason for this is that the vital signs were not found consistently in the documentation at scene or at the OSH. This is an important limitation as the decision to have transported by air may have been made based on scene or OSH vital signs. In other words, the scene or OSH vital signs may have been abnormal and the calculated SIPA may have initially been elevated. Thus, a larger number of patients may have an elevated SIPA at scene or OSH. While this limitation provides a potential avenue for further study to perhaps prospectively collect OSH and scene vital signs for SIPA values at different points of care.

In conclusion, we have demonstrated that our patient cohort had significant means of overtriage by utilizing multiple definitions. Overtriage may be mitigated with clearer guidelines regarding which patients may benefit. As more air ambulance crews are becoming privatized, legislation may be required to stem unnecessary air transportation. Further investigation is warranted to analyze factors associated with barriers to direct transport to a pediatric trauma facility and strategies to expedite transfer.

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