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Impact of prehospital mode of transport after severe injury: A multicenter evaluation from the Resuscitation Outcomes Consortium

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Abstract

BACKGROUND—There is ongoing controversy about the relative effectiveness of air medical versus ground transportation for severely injured patients. In some systems, air medical crews may provide a higher level of care but may require longer transport times. We sought to evaluate the impact of mode of transport on outcome based on analysis of data from two randomized trials of prehospital hypertonic resuscitation.

METHODS—Injured patients were enrolled based on prehospital evidence of hypovolemic shock (systolic blood pressure ≤70 mm Hg or systolic blood pressure = 71–90 mm Hg with heart rate ≤108 bpm) or severe traumatic brain injury (TBI; Glasgow Coma Scale score ≤8). Patient demographics, injury severity, and physiology were compared based on mode of transport. Multivariate logistic regression was used to determine the impact of mode of transport on 24-hour and 28-day survival for all patients and 6-month extended Glasgow Outcome Scale for patients with TBI, adjusting for differences in injury severity.

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DISCLOSURE
The authors declare no conflicts of interest.

RESULTS—Included were 2,049 patients, of which 703 (34%) were transported by air. Patients transported by air were more severely injured (mean Injury Severity Score, 30.3 vs. 22.8; $p < 0.001$), more likely to be in the TBI cohort (70% vs. 55.4%; $p < 0.001$), and more likely blunt mechanism (94.0% vs. 78.1%; $p < 0.001$). Patients transported by air had higher rates of prehospital intubation (81% vs. 36%; $p < 0.001$), received more intravenous fluids (mean 1.3 L vs. 0.8 L; $p < 0.001$), and had longer prehospital times (mean 76.1 minutes vs. 43.5 minutes; $p < 0.001$). Adjusted analysis revealed no significant impact of mode of transport on survival or 6-month neurologic outcome (air transport—28-day survival: odds ratio, 1.11; 95% confidence interval, 0.82–1.51; 6-month extended Glasgow Outcome Scale score ≤4: odds ratio, 0.94; 95% confidence interval, 0.68 – 1.31).

CONCLUSION—There was no difference in the adjusted clinical outcome according to mode of transport. However, air medical transported more severely injured patients with more advanced life support procedures and longer prehospital time.

LEVEL OF EVIDENCE—III.

Keywords

Air medical; emergency medical services; transport: hypovolemic shock; traumatic brain injury

Considerable controversy remains regarding the risks and benefits of air medical versus ground Emergency Medical Services (EMS) transportation for patients who require transport from the scene of injury to a trauma center. Some argue that air medical services provide greater access to advanced life support (ALS) and critical care providers and thus advanced lifesaving interventions, whereas others argue that this is countered by longer transport times in many settings and thus delay to definitive care.

There are conflicting reports of which some demonstrate improved outcome for patients undergoing air transport, whereas others suggest better outcome for those transported by ground EMS.[1–9] A recent analysis of the National Trauma Databank demonstrated that 16% of all injured patients treated in trauma centers were transported by air medical transport from the scene of injury.[1] In this study, patients transported by helicopter were more severely injured, had longer transport times, and had an adjusted higher survival rate than those transported by ground EMS. A major limitation to this study is that ground services close to the trauma center may transport patients with nonsurvivable injuries that would be declared in the field if air transport were required. Most reports in the literature are also limited to a single center or EMS region and are not confined to the most seriously injured patients who are more likely to be impacted by the level of prehospital care provided and duration of transport time.

To address this issue, we conducted a retrospective analysis of prospectively collected data from two randomized controlled clinical trials which enrolled patients with prehospital evidence of severe traumatic brain injury (TBI) or hypovolemic shock.[10] Our objective was to determine whether the mode of prehospital transport impacted outcome for patients enrolled in these trials.

PATIENTS AND METHODS

This analysis is based on data from two clinical trials of out-of-hospital resuscitation with hypertonic saline after TBI and injury with hypovolemic shock conducted by the Resuscitation Outcomes Consortium (2006–2009).[11,12] These studies involved 10 regions in the United States and Canada and included 114 EMS agencies. All sites included patients transported by either ground EMS or air medical transport directly from the scene of injury or a prespecified landing site to a Level I or II trauma center. Interfacility transfers were not included.

Patient Population

Patients were included in the TBI cohort based on a blunt mechanism of injury, age ≥15 years, and a Glasgow Coma Scale (GCS) score of 8 or less and ineligibility for enrollment in the hemorrhagic shock cohort. The hemorrhagic shock cohort included both blunt and penetrating trauma patients with a systolic blood pressure (SBP) ≤70 mm Hg or SBP = 71–90 mm Hg with a heart rate (HR) ≥108 bpm. Patients who met criteria for both cohorts were analyzed in the shock cohort. Exclusion criteria included known or suspected pregnancy, age <15 years, out-of-hospital CPR, administration of more than 2,000 mL of crystalloid or any amount of colloid or blood products before enrollment, severe hypothermia (<28°C), drowning, asphyxia due to hanging, burns involving more than 20% of total body surface area, isolated penetrating head injury, more than 4 hours between receipt of dispatch call and study intervention, prisoner status, and interfacility transfer. For the clinical trial, patients were randomized to receive 250 mL of 7.5% saline, 7.5%saline/6%Dextran-70, or normal saline as the initial resuscitation fluid administered by the EMS providers.

Clinical Data Collection

Detailed prehospital and hospital data were prospectively collected on all patients enrolled in the trials through day 28. Injury severity was determined using the Injury Severity Score based on the Abbreviated Injury Score-98 and the New Injury Severity Score.[13] The Trauma and Injury Severity Score (TRISS) probability of survival was also determined.

Outcome Measures

The primary outcome for the hemorrhagic shock cohort was 28-day survival and for the TBI cohort was neurologic status 6 months after injury based on the Extended Glasgow Outcome score.[14] Because of a 15% rate of missing data for 6-month extended Glasgow Outcome Scale (GOSE), imputation analysis was conducted for this outcome variable, and these imputed data were used for the analysis in this project. The GOSE was dichotomized to good outcome (moderate disability or good recovery) GOSE score >4 versus poor outcome (severe disability, vegetative state, or dead) GOSE score ≤4. For this analysis, we also included 24-hour survival as a secondary outcome.

Data Analysis

The outcome of interest was evaluated for both cohorts combined and the TBI and hemorrhagic shock cohorts independently. For the combined cohorts and shock cohort, we assessed the impact of mode of transportation on 24-hour and 28-day survival. For the TBI cohort, we included both 24-hour and 28-day survival as well as 6-month GOSE using the imputed data set. Demographics, injury severity, mechanism of injury, initial physiology, and prehospital care provided were compared between the air medical and ground EMS transport groups using two-sided Students t test or chi-square tests as appropriate. A $p < 0.05$ was considered significant.

To evaluate the impact of mode of transport on outcome, multivariate logistic regression was used adjusting for gender, age, mechanism of injury, GCS, lowest prehospital SBP, highest prehospital HR, Injury Severity Score (ISS), head Abbreviated Injury Scale (AIS) score, and site of enrollment. To account for missing AIS data which was an issue particularly for those who died before the full extent of their injuries was known, we developed an imputation scheme for ISS scoring. Cases missing ISS were grouped by disposition including death within 6 hours, death after 6 hours, discharge from the emergency department (ED), discharge within 2 days, and discharge after 2 days. The minimum ISS was then calculated from available AIS scores and cases with nonmissing ISS were evaluated within the same disposition category. Imputation was then used to determine the ISS score for missing cases using this information. The variables for the regression analysis were categorized as shown in Table 5. Data are presented as odds ratio with 95% confidence intervals (CIs; SAS, version 9.1.3, Cary, NC; Stata, version 11, College Station, TX).

RESULTS

Between May 2006 and May 2009, a total of 2,222 patients were enrolled in the two clinical trials.[11,12] Patients in the clinical trials who had the fluid bag opened but not given had limited data collection and so are not included in this analysis. Three sites with limited study enrollment were excluded (n = 23) and cases with missing data required for the multivariate analysis were also excluded (n = 62). This left 2,049 patients, 811 in the shock cohort and 1,238 in the TBI cohort. Of these, 703 (34%) were transported by air medical services. The distribution of air versus ground transport for each clinical site is noted in Table 1.

Table 2 shows the demographics, mechanism of injury, injury severity, and initial physiologic data for the entire patient population as well as the shock and TBI cohort individually. There was no difference in age or gender. Overall, patients transported by air were more likely to be victims of blunt rather than penetrating trauma, were more likely to be in the TBI cohort, had a higher ISS and New Injury Severity Score, and had a lower TRISS probability of survival. Patients transported by air also had significantly lower GCS and higher HR. Blood pressure on arrival to the ED was similar between the groups. Hemoglobin on admission was slightly higher in the ground transport group, while evidence of metabolic acidosis (defined a priori as arterial base deficit > 6 mEq/L or lactate >2 mM on the first hospital laboratory sample) was more common in the ground transport cohort.

Table 3 shows the prehospital ALS interventions for each cohort. For both cohorts, patients transported by air were more likely to have an out-of-hospital advanced airway procedure (endotracheal intubation or supraglottic airway), received more intravenous fluids, and had a longer time before administration of the study fluids and a longer total out-of-hospital time.

Unadjusted outcomes by cohort are shown in Table 4. There was no statistically significant difference in survival at any time point when stratified by air versus ground transport. There was a higher proportion of patients with poor neurologic outcome at 6 months in the TBI cohort patients transported by air medical transport. Given the differences in injury severity between the cohorts, as evident in Table 2, we proceeded with a multivariate analysis to evaluate the impact of mode of transportation on outcome after adjusting for these differences.

The results of the multivariate analysis for 24-hour and 28-day survival for the two cohorts combined and individually are shown in Table 5. This analysis showed no significant difference in air versus ground transportation for survival for either cohort when controlling for differences in injury mechanism, injury severity, and initial physiology. Increasing age (age >40 years) and increased injury severity (ISS >15) were associated with lower survival as was SBP ≤80 mm Hg. Within the TBI cohort, air transport was not significantly associated with 6-month GOSE (for GOSE ≤4, odds ratio, 0.94; 95% CI, 0.68 –1.31). For this cohort, age >40 years, ISS >15, and low GCS score were all predictive of poor outcome.

DISCUSSION

There is considerable debate in the current literature regarding the benefits of air versus ground transport for injured patients and the cost-benefit ratio of the utilization of air medical transport.[15] There are conflicting reports evaluating the impact of mode of transport on clinical outcome.[1–3,5,16] Most studies are limited to a single agency or geographic region. In addition, most studies include all patients transported, many of whom are not severely injured and thus less likely to benefit from ALS interventions and rapidity of transport. A recent meta-analysis suggested that 60% of patients transported by helicopter have minor injuries.[17] Several studies have suggested a survival benefit for patients transported by air, but only among those with higher ISS scores.[3,16] However, analysis of a large national cohort of trauma patients demonstrated that those transported by helicopter had improved survival and greater chance of being discharged home despite longer prehospital transport times, greater injury of severity scores, higher rates of admission to intensive care, and greater likelihood of being mechanically ventilated.[1] Two studies have conducted a TRISS analysis and suggested that using this approach air transport is associated with higher than predicted survival.[6,7]

Our study takes advantage of data available from two large multicenter clinical trials of out-of-hospital resuscitation with hypertonic saline. This allows access to data collected for clinical trials, which tend to be of higher quality than administrative datasets. Unlike other studies examining all patients with suspected traumatic injury, the advantage of this dataset for evaluation of the impact of mode of transport on outcome is that it focuses on those with evidence of severe injury at the scene, including hypovolemic shock and severe TBI. These are the patients most likely to be impacted by the level of prehospital care and delays in transport to a trauma center. Importantly, patients requiring out-of-hospital CPR were excluded from the trials and thus there is less likely to be selection bias introduced by preferential ground transportation of these patients. In addition, we include data from 10 geographic regions in the United States and Canada representing 114 EMS agencies suggesting both external validity and generalizability. Another advantage is that all patients whether transported by air or ground had access to basic ALS care for administration of the study fluid and all were transported to a Level I or II trauma center from the scene of injury.

As has been noted in several prior studies, the patients transported by air in this study were more severely injured and were more likely to be victims of blunt trauma. This is likely due to the fact that a selection bias exists for air medical utilization favoring sicker patients and the majority of penetrating trauma occurs in urban areas closer to the trauma center. It is evident that patients who are transported by air have much higher rates of endotracheal intubation, but it is difficult to determine whether this is a reflection of the higher injury severity and higher rate of TBI or better access to providers skilled at rapid sequence intubation (RSI). A recent survey of air medical services suggested that 98.9% of services are using RSI.[18] The availability of RSI among ground EMS agencies remains highly variable.[19,20]

There remains debate in the literature regarding the advantages and disadvantages of out-of-hospital intubation for injured patients. However, a recent randomized clinical trial demonstrated improved outcome for patients with severe TBI randomized to out-of-hospital intubation.[21] There is also evidence that prehospital intubation by skilled air medical crews is associated with improved survival compared with ED intubation of ground transported patients with moderate to severe TBI.[3] Regardless, the differences in injury severity between air versus ground transport emphasize the importance of a multivariate analysis to determine the adjusted impact on outcome.

Another factor that is clearly associated with air transport is longer out-of-hospital times.[22] As air services often transport patients from more remote geographic areas, it is unclear how much of this time is impacted by distance and retrieval conditions. The increase in intravenous fluids administered by air may be simply a factor of this increased transport time rather than a difference in treatment approach. However, we did observe lower rates of metabolic acidosis in the ED for patients transported by air suggesting improved resuscitation en route despite the higher injury severity. Air medical transport may also allow bypass of a local hospital in favor of transport to a major trauma center, which has been associated with improved survival after TBI compared with secondary transfer to a trauma center.[23] In our study, we are unable to evaluate how much delay to definitive care would have been evident if this same patient cohort were transported by ground from remote areas. A previous study suggested that air transport was faster if the scene of injury was greater than 10 miles from the trauma center and simultaneous ground and air dispatch occurred.[24] In the absence of simultaneous dispatch, reduced time was only evident for patients greater than 45 miles from the trauma center. Some authors have advocated local geographic information system mapping to choose the optimal mode of transport to minimize delay to definitive care.[25] Regardless, the observation that the longer out-of-hospital times for air transport were not associated with worse outcome is important particularly for those patients with hemorrhagic shock.

Upon multivariate analysis, we found no impact of mode of transport on survival for either cohort or neurologic outcome for the TBI cohort. This suggests that the decision to utilize air transport should be based on the logistical challenges of a given region and the issues surrounding access to major trauma centers rather than an inherent survival advantage. Other authors have identified a survival advantage in individual regions, which may be impacted by these geographic or care access issues.[3,9,16] For example, Davis et al.[3] reported that for patients with moderate to severe TBI, based on a head AIS score ≥3, air medical transport in the San Diego region was associated with improved survival rates (odds ratio, 1.9; 95% CI, 1.6 –2.25). Another recent meta-analysis of 23 studies indicated that 14 studies suggested a survival advantage to air medical transport, but it was difficult to separate the differences in level of care provided from transport issues.[2] Our results may differ based on the fact that both air and ground transport patients in this study had access to basic ALS care which was required for study enrollment; however, the extent and expertise of ALS care was not uniform across all agencies and no comparison of scope of practice for land versus air personnel was made.

There were several limitations to this study. There were marked differences in the severity of injury between the air and ground transport groups, and although we attempted to adjust for these in the multivariate analysis, there may have been additional covariates not available in the data set. Although the odds ratio for survival favored air transport, we did not reach statistical significance, which may be related to our sample size. In addition, we did not collect information on the distance from the scene of injury to the trauma center, which was likely significantly farther in the air patients as evident by the longer out-of-hospital time. We ran an additional multivariate analysis including total out-of-hospital time as a variable and this did not significantly change the odds ratios for outcome based on air medical versus ground transport. There was also variability among the sites regarding the use of air transport for the study with two sites utilizing ground transport for more than 90% of the patients enrolled and one site using air transport for more than 90% of the patients they enrolled. To account for this, we adjusted for site in the multivariate analysis, but there may have been regional differences in these sites that affected the cohort enrolled. Finally, we lack specific information regarding the ALS skills of the providers in this study.

Air medical assets were developed, in part, to enable better access to specialty care for patients with circumstantial challenges such as geography or limited local medical expertise that might consequentially delay or prevent expert advanced care. Ideally, use of air medical services would overcome these challenges and enable comparable outcomes, similar to those achieved by well-trained ground EMS with more ready access to specialty hospital care. In the current investigation, we found no difference in outcome between ground and air transport suggesting that either approach may be appropriate and that air medical services, implemented in the manner observed in these randomized controlled trials, may overcome limitations of distance and access to specialty care.

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DISCUSSION

Dr. Jeffrey P. Salomone (Atlanta, Georgia): The role of helicopters for the transport of injured patients remains one of the most controversial issues in prehospital trauma care. When I am looking to be provocative with my EMS colleagues, I bring up what I consider to be the four myths of air medical transport.

Myth one is that helicopters are faster than ground EMS. Several studies have now shown that if the scene is in relatively close proximity to the trauma center, such as ten miles, transport by ground is always faster.

The second myth is that helicopters provide a higher level of care. Compared to paramedic services the reality is that most of the expanded scope of practice held by helicopter personnel applies to medical patients and not to trauma patients. While helicopter EMS personnel are trained in rapid sequence intubation, the use of RSI in trauma patients has become controversial since the findings of the San Diego Paramedic RSI Trial were presented at a past AAST meeting. And few helicopter services carry blood.

Myth number three is that helicopters are safe. We have heard of all of the numerous crashes of air medical helicopters in the U.S. over the past decade. In fact, employment as a flight nurse or paramedic now ranks among coal miners and other highly dangerous occupations.

The final myth is that helicopters save lives. Many investigators have attempted to study this issue and demonstrate a difference between outcomes between ground and air medical transport.

One would expect that if helicopter transport did, in fact, make a difference, then the improvement in outcome would be easiest to demonstrate in the most severely injured patients. One striking feature of this study, compared to other analyses of ground versus helicopter transport, is that this cohort is severely injured. This is not surprising considering that it is comprised of data from studies of patients suffering suspected TBI or presumed hypovolemia. But in their adjusted analyses, the ROC investigators found no significant difference in outcome.

This study represents one of the most methodologically sound investigations of the role of helicopter EMS. The manuscript includes a large amount of data and the authors do a nice job of identifying their limitations. Nevertheless, I do have a couple of questions.

In a recently published analysis that showed an improved outcome in trauma patients transported by helicopter compared to ground, I wondered if the findings actually represented difference in outcomes from being cared for in different levels of centers rather than the result of care provided by the helicopter. That is, ground EMS may preferentially transport to lower level community trauma centers while air medical transport may transport to Level I trauma centers, thus demonstrating a survival difference between levels of trauma centers rather than mode of transport. In your study were you able to determine if patients were equally distributed between Level I and II centers in and whether or not this made a difference?

And, lastly, how does this ROC study help us as the trauma surgery community educate our ground and air medical EMS colleagues about the proper indications for air medical transport of patients from the scene to the trauma center?

Again, I’d like to thank Dr. Bulger and the ROC for conducting this investigation and the Association for the opportunity to discuss it.

Dr. Anna M. Ledgerwood (Detroit, Michigan): Nice presentation, Eileen. My question relates to the use of medications. Did you look at the difference in and type of medications that might have been administered by air transport versus ground? I have done site visits, and almost all the air transports I review somehow are getting some medication, particularly narcotics.

Dr. James M. Betts (Oakland, California): I enjoyed the paper. We have about 700 transports a year to our center and it’s only children. And we’ve been concerned because we review all of our helicopter transports quarterly and have found that up to 30% of them are unnecessary or the child could actually go home from the ED as soon as they arrived.

For the centers that you reviewed, how many of them actually owned the helicopter or had control of the helicopter? And what percentage of your patients did you really find had minimal injury and ended up leaving earlier than perhaps they would have?

Lastly, the cost for a transport is somewhere probably between $6,000 and $10,000 per transport. And certainly for our patient population that is 70% indigent care, we're the ones who are going to pay that.

Dr. Jennifer Watters (Portland, Oregon): This is a topic I'm interested in as well. You showed a difference in metabolic acidosis, volume of fluid given, and time prehospital. Do you think that the volume administered was simply related to the additional time spent prehospital or have you been able to tease out whether there are different philosophies between your ground transportation and air transport folks?

Dr. Kenneth L. Mattox (Houston, Texas): Mattox, Houston. I would suggest to all of us that the controversy is fading and it's probably time for us to stop using that "c" word.

So my question is, is it time for the ROC group or this organization or organized medicine to take the power of our convictions and our evidence and make a policy statement on this very expensive advertising mode that does not really alter outcomes?

Dr. David A. Spain (Stanford, California): We just completed a similar analysis of the NTDB using similar methodology and it only looked at those patients who we felt were eligible for helicopter transport, that is those that had a prehospital transport time of more than 30 minutes.

And we actually came to the exact same findings, that there is no real evidence to support the theory that helicopters save lives. So I was wondering if you could look at this as a function of transport time in the prehospital?

Dr. Eileen M. Bulger (Seattle, Washington): I want to thank everybody for those excellent comments and I will try to cover them all pretty quickly. I want to thank in particular our invited discussant, Dr. Salomone.

The first question he asked was about the distribution to different levels of trauma centers. Since this was a randomized, controlled clinical trial, nearly all the centers involved in the trial were Level I trauma centers. In fact, all the centers in the United States were.

The only reason we had Level II in the manuscript is because there were a couple of rural centers in Canada that received patients from the clinical trial that were essentially equivalent to the U.S. Level II.

There were so few patients enrolled in those centers that I don't think it impacted the analysis and so we did not analyze this subgroup.

The next question was what advice this study should give regarding who should be transported by helicopter EMS and really this study doesn't address that issue.

We had a population of patients who were severely injured and so we can't really address from this study the indications for helicopter transport among a broader injured patient population but I think, as Dr. Mattox alluded to, this is a point that we really as a trauma community need to review to make some recommendations.

This is an issue that the EMS Committee at the Committee on Trauma has been looking at and I hope we will continue to move forward in that direction.

Dr. Ledgerwood asked about the use of medications. We do have that data but I did not break that out for this analysis so I can't answer your question.

Dr. Betts talked, again, about the indications, ie the percentage of patients with minimal injury transported by air medical transport. Again, because these patients were enrolled in a clinical trial of hypertonic resuscitation the vast majority were severely injured.

We did have about 10% of the patients, particularly in the TBI cohort, who had a GCS of less than eight in the field and turned out not to have a significant traumatic brain injury. They likely had a very low GCS as a result of intoxication. Because this group represented a very low percentage in this study we cannot comment on the indications for air medical transport overall.

Dr. Watters asked about the relationship between time and the volume of IV fluids infused. I can't really tease that out. My suspicion is that you're right, that air medical patients received more fluid just because they were in transport for a longer period of time. It wasn't drastically more fluid so I don't think it was a major difference in treatment philosophy.

There was a difference in metabolic acidosis on arrival. Air transport patients had a lower rate of metabolic acidosis based on base deficit and lactate than ground transport patients, but I didn't see a major difference in large amounts of fluid.

And, again, I appreciate the comments of Dr. Mattox and Dr. Spain. I do think it's time for the Committee on Trauma and this organization to think about what policy statements need to be made. Thank you.

TABLE 1

Air Versus Ground Transport by ROC Site

Site	**Air (N = 703)**	**Ground (N = 1,346)**
Birmingham, Alabama (N = 177)	84 (47.46)	93 (52.54)
Dallas/Fort Worth, Texas (N = 347)	183 (52.74)	164 (47.26)
Milwaukee, Wisconsin (N = 178)	7 (3.93)	171 (96.07)
Ottawa, Canada (N = 155)	11 (7.10)	144 (92.90)
Pittsburg, Pennsylvania (N = 29)	28 (96.55)	1 (3.45)
Portland, Oregon (N = 150)	27 (18.00)	123 (82.00)
San Diego, California (N = 209)	88 (42.11)	121 (57.89)
Seattle/King County, Washington (N = 471)	131 (27.81)	340 (72.19)
Toronto, Canada (N = 212)	111 (52.36)	101 (47.64)
Vancouver/British Columbia, Canada (N = 121)	33 (27.27)	88 (72.73)

ROC, Resuscitation Outcomes Consortium.

Values are expressed as N (%).

TABLE 2

Demographics, Injury Severity, and Initial Physiology

	Shock and TBI Cohorts (N = 2,049)			Shock Cohort (N = 811)			TBI Only Cohort (N = 1,238)		
	Air Transport N = 703)	**Ground Transport (N = 1,346)**	***p***	**Air Transport (N = 211)**	**Ground Transport (N = 600)**	***p***	**Air Transport (N = 492)**	**Ground Transport (N = 746)**	***p***
Age (yr), mean (SD)	37.8 (17.4)	38.2 (18.0)	0.609	39.2 (17.6)	35.7 (16.1)	0.011	37.1 (17.2)	40.2 (19.2)	0.004
Male gender, N (%)	525 (74.7)	1,055 (78.4)	0.060	154 (73.0)	478 (79.7)	0.048	371 (75.4)	577 (77.3)	0.431
Blunt trauma, N (%)	661 (94.0)	1,051 (78.1)	<0.0001	176 (83.4)	316 (52.7)	<0.0001	485 (98.6)	735 (98.5)	0.941
Penetrating trauma, N (%)	42 (6.0)	286 (21.2)	<0.0001	35 (16.6)	275 (45.8)	<0.0001	7 (1.4)	11 (1.5)	0.941
Shock cohort, N (%)	122 (17.4)	449 (33.4)	<0.0001	122 (57.8)	449 (74.8)	<0.0001	0 (0.0)	0 (0.0)	
TBI only cohort, N (%)	492 (70.0)	746 (55.4)	<0.0001	0 (0.0)	0 (0.0)		492 (100.0)	746 (100.0)	
Shock and TBI cohort, N (%)	89 (12.7)	151 (11.2)	0.338	89 (42.2)	151 (25.2)	<0.0001	0 (0.0)	0 (0.0)	
Lowest prehospital SBP (mm Hg), mean (SD)	93.9 (39.6)	90.7 (49.4)	0.111	57.0 (31.6)	51.4 (36.2)	0.036	109.8 (31.2)	123.3 (33.2)	<0.0001
Highest prehospital HR (bpm), mean (SD)	112.6 (24.5)	107.8 (27.9)	<0.0001	122.8 (23.4)	114.4 (27.8)	<0.0001	108.2 (23.6)	102.4 (26.8)	<0.0001
Out-of-hospital GCS score, mean (SD)	6.2 (3.8)	7.4 (4.5)	<0.0001	9.5 (5.0)	10.3 (4.9)	0.049	4.7 (1.9)	5.2 (2.2)	0.0002
ISS, mean (SD)	30.3 (15.1)	22.8 (16.0)	<0.0001	28.3 (15.2)	22.0 (16.2)	<0.0001	30.1 (15.1)	23.4 (15.7)	<0.0001
Head AIS score	3.0 (2.0)	2.2 (2.1)	<0.0001	1.6 (2.0)	1.0 (1.8)	<0.0001	3.6 (1.8)	3.1 (1.9)	<0.0001
Chest AIS score	2.1 (1.8)	1.4 (1.8)	<0.0001	2.4 (1.8)	1.7 (1.9)	<0.0001	2.0 (1.8)	1.2 (1.7)	<0.0001
Abdomen AIS score	1.0 (1.4)	0.9 (1.5)	0.116	1.6 (1.7)	1.3 (1.7)	0.087	0.8 (1.3)	0.6 (1.1)	0.003
Extremity AIS score	1.4 (1.4)	1.1 (1.4)	0.0003	1.9 (1.5)	1.4 (1.5)	0.001	1.1 (1.3)	0.9 (1.3)	0.0002
NISS, mean (SD)	38.3 (18.1)	30.1 (20.1)	<0.0001	34.7 (16.6)	28.6 (19.4)	<0.0001	39.9 (18.5)	31.2 (20.5)	<0.0001
RTS, mean (SD)	5.0 (1.5)	5.1 (1.6)	0.046	5.4 (2.0)	5.3 (2.1)	0.682	4.8 (1.1)	5.0 (1.2)	0.007
TRISS probability outcome, mean (SD)	0.62 (0.31)	0.70 (0.31)	<0.0001	0.68 (0.32)	0.70 (0.34)	0.499	0.59 (0.30)	0.70 (0.28)	<0.0001
Admission SBP (mm Hg), mean (SD)	125.9 (38.1)	126.6 (40.7)	0.696	103.5 (41.8)	108.1 (41.6)	0.168	135.4 (31.9)	141.0 (33.5)	0.003
Admission hemoglobin (g/dL), mean (SD)	11.7 (2.6)	12.0 (2.5)	0.008	10.3 (2.6)	10.8 (2.5)	0.016	12.2 (2.5)	12.9 (2.1)	<0.0001
Admission metabolic acidosis, N (%)[*]	253 (73.6)	501 (84.1)	<0.0001	85 (83.3)	238 (89.1)	0.141	168 (69.4)	263 (79.9)	<0.0001

[*] Arterial base deficit >6 mEq/L or lactate >2 mM.

TABLE 3

Out-of Hospital Care Provided

	Shock and TBI Cohorts (N = 2,049)			Shock Cohort (N = 811)			TBI Only Cohort (N = 1,238)		
	Air Transport (N = 703)	**Ground Transport (N = 1,346)**	***p****	**Air Transport (N = 211)**	**Ground Transport (N = 600)**	***p****	**Air Transport (N = 492)**	**Ground Transport (N = 746)**	***p****
Out-of-hospital advanced airway, N (%)	568 (80.8)	486 (36.1)	<0.0001	121 (57.3)	178 (29.7)	<0.0001	447 (90.9)	308 (41.3)	<0.0001
Out-of-hospital fluids (L), mean (SD)	1.3 (1.0)	0.8 (0.6)	<0.0001	1.7 (1.2)	1.0 (0.7)	<0.0001	1.1 (0.8)	0.7 (0.5)	<0.0001
Time from 911 call to fluid admin (min), mean (SD)	48.5 (27.9)	25.2 (14.4)	<0.0001	47.5 (26.7)	25.0 (16.8)	<0.0001	48.9 (28.4)	25.5 (12.1)	<0.0001
Total out-of-hospital time (min), mean (SD)	76.1 (32.4)	43.5 (17.9)	<0.0001	77.1 (29.1)	42.8 (20.5)	<0.0001	75.6 (33.8)	44.1 (15.6)	<0.0001

TABLE 4

Outcome Measures

	Shock and TBI Cohorts (N = 2,049)			Shock Cohort (N = 811)			TBI Cohort (N = 1,238)		
	Air Transport (N = 703)	**Ground Transport (N = 1,346)**	***p****	**Air Transport (N = 211)**	**Ground Transport (N = 600)**	***p****	**Air Transport (N = 492)**	**Ground Transport (N = 746)**	***p****
28-d survival, N (%)	520 (74.0)	1,038 (77.1)	0.115	158 (74.9)	462 (77.0)	0.535	362 (73.6)	576 (77.2)	0.145
24-h survival, N (%)	595 (84.6)	1,144 (85)	0.831	171 (81.0)	489 (81.5)	0.884	424 (86.2)	655 (87.8)	0.405
Survival at hospital discharge, N (%)	507 (72.7)	1,029 (76.6)	0.055	154 (73.7)	459 (76.6)	0.395	353 (72.3)	570 (76.6)	0.091
Death in the field, N (%)	2 (0.3)	7 (0.5)	0.427	1 (0.47)	6 (1.0)	0.450	1 (0.20)	1 (0.13)	0.769
Death in the field or ED, N (%)	38 (5.4)	85 (6.3)	0.407	16 (7.6)	51 (8.5)	0.675	22 (4.47)	34 (4.56)	0.943
Death within 6 h of ED admission, N (%)	65 (9.2)	139 (10.3)	0.436	28 (13.3)	89 (14.8)	0.575	37 (7.52)	50 (6.70)	0.583
6-mo GOSE score ≤4, imputed values, N (%) (TBI only)							290.4 (59.0)	3360.2 (48.3)	<0.001

TABLE 5

Multivariate Analysis for 28 d and 24 h Survival

	28-Day Survival Odds Ratio (95% CI)*	**24-Hour Survival Odds Ratio (95% CI)***
Shock and TBI cohorts		
Air transportation	1.11 (0.82, 1.51)	1.23 (0.86, 1.74)
Shock cohort		
Air transportation	1.31 (0.76, 2.25)	1.26 (0.72, 2.20)
TBI only cohort		
Air transportation	0.91 (0.63, 1.33)	1.03 (0.66, 1.61)