COLLECTIVE REVIEW

HELICOPTER EMS TRANSPORT OUTCOMES LITERATURE: ANNOTATED REVIEW OF ARTICLES PUBLISHED 2004–2006

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ABSTRACT

Helicopter EMS (HEMS) and its possible association with outcomes improvement continues to be a subject of debate. As is the case with other scientific endeavors, debate over HEMS usefulness should be framed around an evidence-based assessment of the relevant literature. In an effort to facilitate the academic pursuit of assessment of HEMS utility, in late 2000 the National Association of EMS Physicians' (NAEMSP) Air Medical Task Force prepared annotated bibliographies of the HEMS-related outcomes literature. As a result of that work, two review articles, one covering HEMS use in nontrauma and the other in trauma, published in 2002 in *Prehospital Emergency Care* surveyed HEMS outcomes-related literature published between 1980 and mid-2000. The project was extended with a 2004 review that covered the literature published between 2000 and 2003. The current review continues the series, outlining outcomes-associated HEMS literature from 2004 through 2006. **Key words:** HEMS; helicopter transport; outcomes; trauma; nontrauma; scene; interfacility.

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INTRODUCTION

Despite the frequency of HEMS transport, and the controversy that surrounds its cost and benefit, there are few comprehensive reviews encapsulating extant HEMS outcomes-related research. In 2002, two annotated bibliographies, prepared by the National Association of EMS Physicians' (NAEMSP) Air Medical Task Force, addressed the HEMS outcomes-related literature for trauma and nontrauma diagnoses.[1,2] Although commentary was provided for each article, the bibliographies and their summaries of over 50 studies were intended to serve primarily as a central reference listing to aid parties interested in HEMS research. The bibliography has been updated once, to cover studies published through 2003.[3] The current article intends to extend the previous reviews by assessing outcomes studies published 2004–2006. As with previous reviews in the series, the article summaries include commentary intended to place the research into perspective, but the primary goal of this article is to present the most important HEMS outcomes literature published in the 2004–2006 time frame.

METHODS

A computerized literature search was performed. The search database was the National Library of Medicine's MEDLINE (online Index Medicus), extending from 2004 through 2006. The search methods and terminology used for this review were the same as those used, and reported, in the previous reviews.[1–3] For the current review, there were approximately 500 studies assessed for possible inclusion (by review of title, abstract, or full-length article).

As noted for the previous reviews, eligibility for article inclusion was usually easily determined, but there was inevitably some degree of subjectivity. Some articles that are *not* summarized in this bibliography are noteworthy. For example, a 2005 *JAMA* study found that HEMS represented the *only* mechanism by which 27% of the U.S. population (81.4 million people) had timely Level I or II trauma center access (within an hour of receipt of emergency call).[4] The authors concluded that new helipad placements and additional HEMS programs "could be an important, and practical, means of extending trauma center access to populations that currently have none."[4] Because the *JAMA* study group comprised both clinical and epidemiological leaders in trauma systems, their paper—with its statement that

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HEMS is useful from a time-distance perspective—is a useful complement to the HEMS utility dialogue. An equally well-respected group, addressing HEMS use in a nontrauma population, has written "we firmly believe air medical transport is a safe means for transport of cardiac patients and should be considered for patients who require transfer to more specialized centers for additional diagnostic and therapeutic interventions."[5] Neither of these articles fits into the subjective definition of a "HEMS outcomes study," so they are not further discussed in this review.

The articles that are included in this review are categorized into diagnostic areas. The first category, General Trauma, assesses studies of HEMS use in transporting injured patients. The next category, Head Injury, addresses the use of HEMS for a subset of trauma patients. The review concludes with an overview of HEMS use for Neonatal transports. Within categories, articles are listed chronologically.

General Trauma

- Frankema SPG, Ringburg AN, Steyerberg EW, Edwards MJR, Schipper IB, van Vugt AB. Beneficial effect of helicopter emergency medical services on survival of severely injured patients. Br J Surg. 2004;91:1520–6.

Objective

The study's objective was to assess whether the Dutch model of helicopter dispatch to trauma scenes (with subsequent ground transportation to trauma centers) was associated with survival benefit compared wotj the traditional mechanism of ground EMS response and ground transfer.

Methods

Study Design

The study was a prospective trauma database review with assessment of prehospital and hospital records.

Setting

The setting was the Erasmus Medical Centre, a trauma center in Rotterdam. The HEMS operations (four services covering most of the Dutch population, operating during daylight hours) are staffed with a physician and a paramedic. HEMS crews have extended capabilities (e.g., advanced airway management with neuromuscular blockade compared with non-RSI ETI done by ground providers) beyond those of the ground EMS crews that also respond to all trauma.

Time Frame

Study patients were those who arrived at the study hospital between 2000 and 2002.

Patients

Study patients were all (n = 346) adult (>15 years old) trauma scene transports to the study center during the study period; 239 were cared for solely by ground EMS and 107 had additional HEMS response. Patients were excluded from analysis if they had inevitably fatal injuries (Abbreviated Injury Scale/AIS code 6), if they were dead on arrival at the study trauma center, or if they had a drowning or strangulation mechanism of injury.

Analysis

The analysis using 90-day mortality outcome and custom-fitted logistic regression was rigorous, and included many aspects beyond the scope of this review. The authors, finding that the New ISS (NISS) was the best predictor of mortality in the overall population, used this scale as the main acuity control. The RTS was incorporated by components (rather than as a whole score), and the multivariate model also incorporated age and trauma mechanism.

Results

Like most HEMS trauma studies, the crude mortality was much higher for HEMS patients, but control for acuity reversed the association. Outcomes point estimates favored HEMS in 9 of 10 analyses; penetrating trauma was the only group for which the (nonsignificant) outcome impact point estimate of 0.2—with a wide 95% CI: 0.01–5.8—was on the side of better outcome with ground EMS. In the overall group (all patient types), the HEMS mortality improvement just failed to reach statistical significance (point estimate for better chance of survival, 2.2 with 95% CI: 1.0–5.9, and p value 0.076). In the group of blunt trauma patients, the HEMS-associated mortality improvement was statistically significant (OR: 2.8; 95% CI: 1.1–7.5; p = 0.036). For patients with severe head injuries (cranial ISS > 9), HEMS response was associated with borderline-significant outcome improvement (OR: 3.0; 95% CI: 0.99–8.8; p = .052).

Authors' Conclusions

HEMS was called for patients of higher injury acuity and diminished vital signs. HEMS response resulted in improved outcome for patients with blunt trauma and for those with severe head injuries. The authors point out that because ground EMS providers already have capabilities for non-RSI ETI and needle thoracostomy, the outcomes benefit from HEMS providers may

be related to extended-scope airway management as well as more crew experience and expertise with multiple trauma patients.

Commentary

This study has the advantage of being methodologically rigorous (particularly with respect to the statistical analysis and control for many variables) as well as prospective. Like an earlier Dutch study[4] addressed in a prior *Prehospital Emergency Care* HEMS review, the aritcle by Frankema may have a generalizability problem. To wit, because HEMS responds to the scene and crews provide on-site care, followed in up to 85% of cases by *ground* transport to trauma centers, one would initially wonder if improved outcome findings applied in other situations. However, the fact that trauma centers were close by (an average of only 13 ground minutes away) means that the time savings accrued by air transport from the scene would have been negligible anyway. Therefore, this study provides good evidence for air medical crew interventions' mortality impact, leaving the time issues for other investigations (i.e., in areas with longer transport times).

- Biewener A, Aschenbrunner U, Rammelt S, Grass R, Zwipp H. Impact of helicopter transport and hospital level on mortality of polytrauma patients. J Trauma. 2004;56:94–8.

Objective

The study's objective was to assess whether trauma mortality was impacted by two major variables: ground versus air transport, and direct versus indirect trauma center transfer (i.e., straight from injury scene to trauma center vs. initial transport to regional hospital with secondary transport—sometimes days later—to the trauma center).

Methods

Study Design

The study was a retrospective analysis of trauma center and regional hospital data.

Setting

The setting was a 50-km radius around Dresden, Germany.

Time Frame

Study patients were those who were transported during the 24-month period 1998–1999.

Patients

Study patients were those who had blunt mechanism polytrauma with ISS at between 16 and 67 (mean for all groups was in the range of 33–36), who arrived alive at a hospital, and who were 75 years of age or younger. Patients were those who were transported to one of six regional hospitals (by ground) or into the university trauma center (by ground or air, from either scenes or from one of the six regional hospitals).

Analysis

The analysis used 30-day mortality as the end point. Methodology was multivariate and TRISS-based, with additional adjustment for the time interval between the trauma incident and initial arrival at an emergency department. TRISS was not able to be calculated in patients who were cared for solely at regional hospitals; multivariate models incorporating those patients were adjusted for ISS and age.

Results

Ground transported patients who went directly into the trauma center had the lowest mortality of the four groups, but the difference was not statistically significant. For the patients transported by air or ground directly into the trauma center, there was no transport modality-associated difference in unexpected survival or death. In considering the patients who were taken directly to the trauma center, the ground-transported cohort was noted to be "slightly less injured and younger" than the air-transported patients. As emphasized by the authors, the main comparison in the study was between those patients transported by air directly to the trauma center and those patients transported by ground ambulance to regional centers (without subsequent transport to the university hospital). Overall mortality, and particularly mortality for patients with ISS exceeding 40, was significantly higher in patients transported by ground to, and receiving all of their care at, regional facilities. Ground transport to regional hospital care was associated with nearly double the mortality of HEMS transport to a trauma center (41.2% vs. 22.1%; $p = .002$). Despite the fact that both transport vehicle types are physician-staffed, patients transported by the HEMS crews underwent significantly more prehospital procedures (e.g., intubations, chest tube placement) than did those patients ground-transported from scenes to the university center.

Authors' Conclusions

When transporting blunt trauma patients from within the city (i.e., close to the trauma center), there is no benefit from air compared to ground transport. In considering the main study comparison, direct air transport to

trauma center versus ground transport to regional hospitals (without subsequent trauma center transfer), the region's logistics (e.g., intermittent HEMS unavailability) generated a form of "randomization" to either air transport to the trauma center or ground transport to a regional hospital. The authors conclude that compared to ground/regional hospital care, HEMS/university care is associated with marked survival improvement. The main reason for the improved survival is direct access to the trauma center, rather than any high-level care provided by the HEMS crews.

Commentary

The authors' contention that HEMS is not likely useful for within-city responses is consistent with common sense. In the absence of traffic congestion, it seems unlikely that HEMS will routinely offer improved survival chances to patients at trauma scenes relatively close to trauma centers. The most compelling results from the article are those that deal with trauma occurring outside the city. For this group, there is a doubling in mortality associated with (ground) transport to a regional hospital compared with air transport direct from trauma scenes to university-level care. This is consistent with emerging trauma literature showing that rapid transport to high-level trauma care is lifesaving.[5] As is common with HEMS studies, the authors are forced to speculate on the reasons for survival benefit accrued by air transport into trauma centers. Further studies must focus on the question of "how," but this study does an excellent job of portraying the mortality increment associated with air transport directly into high-level trauma center care. As the distance from trauma scenes to Level I care grows and HEMS becomes the only mechanism for rapid access to advanced care, the combination of HEMS and high-level trauma centers improves outcome.

- Buntman AJ, Yeomans KA. The effect of air medical transport on survival after trauma in Johannesburg, South Africa. South African Med J. 2005;92:807–11.

Objective

The study's objective was to assess whether outcome for trauma patients was improved with air, compared with ground, transport from trauma scenes to trauma centers.

Methods

Study Design

Prospective TRISS-based trauma database review with assessment of prehospital and hospital records.

Setting

The study was conducted out of "private sector" (Milpark Hospital) and "public sector" (Johannesburg Hospital) trauma centers. HEMS coverage was variable over the study period, with a total of three services operating (at least one on a 24-hour basis). HEMS patients received "sophisticated advanced life support" while ground transported patients (which group included an unknown number of those presenting by private vehicle) received lesser care from a variety of levels of prehospital providers.

Time Frame

Study patients were those who arrived at the study hospitals between 1999 and 2000.

Patients

Study patients were all (n = 428) trauma patients coming to the study center during the study period; 122 were transported by HEMS and 306 by ground. Patients were excluded from analysis if they had no vital signs on trauma unit arrival.

Analysis

The analysis end point was survival to hospital discharge. TRISS was used to determine the "actual" versus "expected" deaths, and the Z score was used to calculate whether the difference between actual and predicted death numbers was significant for air versus TRISS (MTOS), ground versus TRISS (MTOS), and—most importantly for this review—air versus ground. The authors justified the use of TRISS despite low M statistic calculations, by noting that problems were minimized by direct air-to-ground comparison.

Results

Like most HEMS trauma studies, the crude mortality was much higher for HEMS patients, but control for acuity reversed the direction of the association. In the HEMS group, patients died at the TRISS-predicted rate (38 deaths predicted, 39 actual deaths); in the ground group, patients died at a significantly higher rate than TRISS predicted (39 predicted, 51 actual deaths). The difference between air and ground predicted/actual deaths was statistically significant; the authors reported that HEMS reduced mortality by 21.4%. Subanalyses suggested that the HEMS effect on survival was most pronounced in patients with a TRISS-predicted survival chance under 50%.

Authors' Conclusions

HEMS transport reduces mortality in trauma patients transported from the scene. Because HEMS transport

times were often as long as, or longer than, ground transport times, the survival impact was believed to be due to some combination of speed and advanced care.

Commentary

There are oddities to the study's methodology, and the usual TRISS-related concerns are present. Concerns about the too-low M statistic are not completely alleviated by the authors' employment of a ground cohort. That said, the direct comparison of air versus ground transported patients and the multivariate analysis that largely accounted for relevant confounders serves to strengthen the authors' message. It is of interest that although the details of the calculation of HEMS benefit differ from some other TRISS studies, the authors' result of a little over 20% mortality reduction is quite consistent with results from many other HEMS studies.

- DiBartolomeo S, Sanson G, Nardi G, Michelutto V, Scian F. HEMS vs. ground-BLS care in traumatic cardiac arrest. Prehosp Emerg Care. 2005;9:79–84.

Objective

The study's objective was to assess whether high-level prehospital care improves outcome of blunt trauma victims found in cardiac arrest.

Methods

Study Design

Prospective database review with assessment of prehospital and hospital records.

Setting

The study was conducted in northeast Italy, in a region comprising approximately 1.2 million persons. HEMS units were staffed by dedicated anesthesiologists and nurses, whereas ground units were staffed by an EMT/nurse crew with a lesser practice scope (they had capability for IV infusion, defibrillation, and emergency medications). For all HEMS transports, ground ambulances were simultaneously dispatched.

Time Frame

The study assessed EMS responses during a 12-month period in 1998–1999.

Patients

Study patients were 129 patients who were in blunt trauma arrest at the scene; 56 were transported by HEMS and 73 by ground EMS. Patients were eligible for study if they were found pulseless and apneic by the (air or ground) rescue team; subjects were excluded from analysis if they had ISS less than16 or if their injuries were self-inflicted.

Analysis

The primary analysis end points were survival and neurological status. The authors collected other data, such as successful performance of various prehospital interventions, but there was no detailed analysis of that information in terms of HEMS versus ground comparisons.

Results

Although the groups were reported as homogeneous for injury mechanism, gender, and time interval prior to CPR, HEMS patients were not equivalent to ground EMS patients. For instance, the mean age was 15 years higher for the air cohort (50 vs. 35 years). HEMS patients were also twice as likely to have undergone on-scene CPR, and the time interval between initial EMS call and ultimate hospital arrival was markedly longer for HEMS patients (54 vs. 17 minutes). On-scene return-of-spontaneous-circulation (ROSC) was noted in 16% of HEMS patients, compared to only 1% of ground EMS patients. The survival rate of 3.6% for HEMS patients was a statistically nonsignificant higher number than the zero survival found in the ground EMS cohort; furthermore, the surviving patients had poor neurological outcome. In terms of interventions, comparison for most variables (e.g., intubation, chest decompression) would not be appropriate because ground providers were unable to perform these maneuvers. However, for IV placement, a procedure that was within the practice scope of both air and ground providers, the HEMS patients were more likely to have the procedure successfully done in the field (95.8% for HEMS vs. 73.3% for ground EMS; analysis for this review finds a borderline-significant Fisher's exact p of 0.06).

Authors' Conclusions

Compared with ground transport, HEMS response was associated with a sixfold increase in achievement of on-scene ROSC in patients in whom CPR was started. This was due to air crew performance of procedures exclusive to HEMS (i.e., intubation, chest decompression, aggressive intravenous fluid therapy, and expanded pharmacotherapy). Shorter prehospital time intervals associated with ground EMS and the potential for rapidly getting patients to definitive care failed to offset the ground units' inability to perform prehospital interventions. The authors concluded that "a top-level type of prehospital care had significantly more chances

to resuscitate blunt trauma victims found in cardiac arrest."

Commentary

This article, from a group known for producing a stream of excellent EMS research articles, assessed a patient population—blunt trauma arrest—in whom outcome is virtually always poor. Such a study design was almost preordained to be underpowered, given the rarity of good outcome. In fact, the authors report that their 3.5% survival rate (albeit with poor neurological outcomes) is relatively high for the population they studied. If, as the authors report, a sufficiently powered study (about 100 patients in each group) could confirm their results and reach statistical significance, the data would have more impact. Given the existing data, however, HEMS dispatch to patients who are known to be in blunt trauma arrest seems to represent a poor use of air medical resources.

- Bledsoe BE, Wesley AK, Eckstein M, Dunn TM, O'Keefe MF. Helicopter scene transport of trauma patients with nonlife-threatening injuries: A meta-analysis. J Trauma. 2006;60:1257–66.

Objective

The study's objective was to assess the proportion of scene HEMS responses performed for patients who turned out to have injuries that were not life-threatening.

Methods

Study Design

This was a meta-analysis.

Setting

The meta-analysis comprised multiple studies, nearly all of which were conducted in the United States, Europe, or Australia.

Time Frame

Analysis included studies conducted between 1983 and 2004.

Patients

The meta-analysis patients were those from 22 studies who met the following criteria: published in the peer-reviewed English-language literature; assessed HEMS scene response for trauma; used trauma acuity scoring with ISS, TS, RTS, or TRISS.

Analysis

The analysis end points were TS 13 or higher, RTS greater than 11, weighted RTS at least 4, ISS 15 or less, TRISS-derived probability of survival (P_s) at least 90%, and trauma center discharge within 24 hours of flight. (Originally planned analysis of RTS was not performed because of this score was only encountered in a single study; that study's results were included in the ISS results.)

Results

In 13 studies comprising 31,244 patients, there was sufficient information to allow stratification of ISS; the proportion of patients with ISS 15 or less was 60.0% (95% CI: 54.5–64.8%). In two studies (2,110 total patients), there was sufficient information to allow stratification of TS; the proportion of patients with TS 13 or higher was 61.4% (95% CI: 60.8–62.0%). In 11 of the studies (6,328 patients), there was sufficient information to allow stratification of TRISS P_s; the proportion of patients with P_s at least 90% was 69.3% (95% CI: 58.5–80.2%). There were five studies (1,850 patients) providing sufficient information to enumerate patients discharged from receiving trauma centers within 24 hours of HEMS transport; the proportion of patients discharged within 24 hours of HEMS transport was 25.8% (95% CI: minus 0.9 [*sic*]-52.6%).

Authors' Conclusions

HEMS response is characterized by overtriage and overuse. Improved field triage is necessary to optimize use of the HEMS resource.

Commentary

This study is only an outcomes study in the sense that it reports that many trauma outcomes from HEMS are good but not because of any contribution by air transport. The study is included in this review because it cogently presents some of the most compelling "anti-HEMS" arguments from some of that position's best-known advocates.

Some statistical issues warrant mention, if only to underline the difficulty of doing a rigorous meta-analysis of HEMS outcomes. The authors failed to generate a Cochrane-type forest plot for visual depiction of the results. They pooled individual studies and weighted sample sizes, rather than mathematically penalizing the results from smaller studies; this underestimates variance and overly narrows confidence intervals. Analysis of (binomially distributed) means is also curious. It is difficult to tell how the results may have changed as a result of these methodologic quirks, without doing a more traditional and rigorous meta-analysis—an

endeavor that may or may not be possible given the broad heterogeneity of the HEMS literature.

Despite myriad methodological issues with the authors' approach, the study does establish their case for overtriage. When 60% of 31,244 patients have a given characteristic (ISS < 16), no statistical fine-tuning is necessary to make a point that low ISS is commonly seen.

It is unlikely that readers will be surprised that retrospective assessment of HEMS transports identifies many nonseriously injured patients. The question, as appropriately raised by the authors, is how to use *prospectively available information* (certainly not the ISS) to maximize triage sensitivity while maintaining acceptable positive predictive value.

Pointing out poor HEMS triage specificity—even using as a primary indicator a parameter (ISS) that can only be calculated after hospitalization—does represent an addition to the HEMS body of knowledge. However, the authors statement that "future studies should critically evaluate each mechanism of injury and physiologic criteria to determine the best predictors of helicopter usage seems to give short shrift to extant trauma triage data. For instance, the authors mention of using GCS and heart rate (in the manner of a speculation by Moront et al.[6]) manages to combine variables that have already been demonstrated (by Henry et al.,[7] among others) to be insensitive (GCS) and nonspecific (heart rate).

Triage is at the heart of the HEMS debate. A detailed discussion is beyond the scope of this review (readers are referred to Prehospital Emergency Cares July-September 2006 issue), but some points are noteworthy. First, efforts to refine triage should be informed by the knowledge that the American College of Surgeons accepts up to 50% trauma center overtriage to achieve optimal trauma system sensitivity.[7] Second, the difficulty of HEMS triage is underlined by the fact that prehospital personnel do no worse than community hospital physicians who call HEMS for interfacility trauma transports.[8,9] Third, rapid transport to trauma centers saves lives,5 and much of the U.S. population can *only* reach Level I centers in timely fashion by HEMS.[10,11] It seems difficult, if not unfair, to expect that HEMS triage will be significantly better than trauma center triage in general. Until ongoing efforts to refine trauma center triage further illuminate triage issues from system and HEMS perspectives,[12] it would appear wise to concentrate on use review to identify areas in which HEMS dispatch departs from regional criteria—criteria that are necessarily imperfect but are still useful.

Head Injury

- Wang HE, Peitzman AB, Cassidy LD, Adelson PD, Yealy DM. Out-of-hospital endotracheal intubation and outcome after traumatic brain injury. Ann Emerg Med. 2004;44:439–50.

Objective

The study objective was to assess the mortality and functional outcome effects associated with prehospital intubation (ETI) in patients with severe head injury.

Methods

Study Design

The study assessed prospectively collected data from the Pennsylvania Trauma Outcome Study (a registry of all patients treated in the state). A large number of demographic, injury, treatment, and outcome variables were collected.

Setting

The study was conducted in Pennsylvania, with interventions being provided by a variety of prehospital and trauma center providers (at 25 centers) in that state. Prehospital patients were intubated by prehospital ground paramedic or air medical crews (paramedic, nurse, and/or physician providers). Neuromuscular blockade was more widely available to those undergoing air rather than ground transport.

Time Frame

Study patients were consecutive transports occurring between 2000 and 2002.

Patients

Subjects included 4,098 adults (18 and older) transferred directly, by advanced life support units, from the scene to the trauma center (interfacility transports were excluded). Patients were those with severe head injuries (head/neck Abbreviated Injury Scale/AIS score 3 or higher), intubated either in the prehospital or ED setting.

Analysis

Multivariate analysis incorporated myriad demographic, injury, treatment, and outcome parameters; the logistic regression model was adjusted with propensity scoring.

Results

The authors' overall results, which addressed the effect of prehospital (compared with ED) ETI, were that prehospital ETI was associated with a fourfold risk of mortality, and worsened functional status in surviving patients. However (see details below), both mortality and

functional outcome were *improved* in air transported patients.

Authors' Conclusions

The worsening in overall outcome associated with prehospital ETI probably reflects issues with performance of ETI, rather than an inherent danger in provision of an airway to the head-injured patient. The improved outcome associated with transport mode could reflect the fact that air medical crews are "generally more skilled at ETI and carry neuromuscular blocking agents," or it could have "simply reflected the effect of [faster] transport time to trauma center."

Commentary

This study's methodology, starting with information collection measures and continuing through database quality assurance and performance of meticulous multivariate modeling, sets a standard for excellence. Further credence is given to the authors' results by the fact that the study was truly population-based. Important shortcomings of the study were noted (e.g., lack of identifying number of ETI attempts or failed ETIs, absence of transport times), and the analysis addressed study shortcomings where possible. Those results with applicability to this review included mortality and morbidity findings, which, as the authors point out, were not part of the primary study goal and which should thus be viewed with circumspection. With that caveat, the results with respect to transport mode were compelling: ground transport was associated with a 2.28 X increase in risk of mortality (95% CI for odds ratio: 1.83–2.85) and a 1.39 X increase in risk of poor neurologic outcome (95% CI for OR: 1.00–1.91). Not only do the results make a strong case for HEMS-mediated improvement in traumatic brain injury outcome, they begin to point at a candidate for the mediator of such improvement: airway management. This conclusion was noted in the commentary that appeared with the article:

> Their data show that out-of-hospital ETI performed by trained flight EMS providers using a rapid sequence intubation protocol was associated with decreased mortality and improved neurologic outcome. This suggests that there may be something in the technical expertise of the flight crew or in the airway management practices after ETI that has potent effects on outcome." [Zink BJ, Maio RF. Out-of-hospital ETI in traumatic brain injury. Ann Emerg Med. 2004;44:451–3]

- Davis DP, Peay J, Serrano JA, Buono C, Vilke G, et al. The impact of aeromedical response to patients with moderate to severe traumatic brain injury. Ann Emerg Med. 2005;46:115–22.

Objective

The study objective was to assess the mortality and functional outcome effects associated with HEMS versus ground transport of patients with severe head injury.

Methods

Study Design

The study retrospectively assessed data from the San Diego County Trauma Registry. A large number of demographic, injury, treatment, and outcome variables were collected.

Setting

The study was conducted in California, with interventions being provided by two ground paramedics responding to all major trauma; patients were either transported by those ground units or HEMS (which had variable staffing comprising flight nurses, emergency medicine resident physicians, and paramedics). HEMS crews had access to neuromuscular blocking drugs, whereas ground EMS units did not. Patients were cared for at five adult Level I or II trauma centers.

Time Frame

Study patients were consecutive transports occurring between January 1987 and December 2003.

Patients

Subjects included 3,017 HEMS and 7,295 ground-transported adults transferred directly from trauma scenes to trauma centers. The study patients were those with severe head injuries (head/neck Abbreviated Injury Scale/AIS score 3 or higher).

Analysis

Multivariate analysis incorporated myriad demographic, injury, treatment, and outcome parameters; the logistic regression model was adjusted with propensity scoring.

Results

The authors' overall results adjusted for ISS, head AIS, age, sex, injury mechanism, prehospital GCS and hypotension. In multivariate analysis, HEMS compared to ground transport was found to improve survival and functional outcome (OR: 1.9; 95% CI: 1.6–2.3) in the overall group. Subgroup analyses also yielded significant outcome improvements for patients with AIS 3 (OR: 1.9; 95% CI: 1.2–3.0) and AIS 4+ (OR: 1.7; 95% CI:

1.4–2.0). Subgroup analysis also found HEMS yielded statistically significant outcome improvement for patients with GCS between 3 and 8 (OR: 1.8; 95% CI: 1.5–2.2). There was no statistically significant improvement for patients with higher GCS scores, but the point estimates were in favor of HEMS for both groups; the wide 95% CIs were as would be expected given low mortality in such patients (for GCS 9–12, OR for HEMS outcome improvement was 1.2 with 95% CI: 0.6–2.2; for GCS 13–15 OR was 1.2 with 95% CI: 0.7–2.1). In one final analysis, prehospital ETI by HEMS crews was found to improve outcome compared with ED ETI (OR: 1.4; 95% CI: 1.1–1.8), whereas prehospital *ground* EMS ETI *worsened* outcome.

Authors' Conclusions

Aeromedical response appears to result in improved outcomes after adjustment for multiple influential factors in patients with moderate to severe traumatic brain injury. Out-of-hospital ETI among air transported patients resulted in better outcomes than ED ETI, which was done for ground transported patients.

Commentary

This study's methodology approaches the best that can be hoped for in a large-scale prehospital trauma outcomes study. The message is underlined by its focused study group (head injury), large numbers, and myriad covariates. The authors' conclusions also are strengthened by the consistency of HEMS-positive point estimates (most of them statistically significant) for a variety of outcomes in many groups, and the use of elegant multivariate methods (including propensity scoring). The study still doesn't definitively answer the question of *why* (HEMS improves outcome), but the focus on airway management certainly lays a solid foundation for at least part of the survival improvement being due to ETI skills.

- Davis DP, Stern J, Ochs M, et al. A follow-up analysis of factors associated with head-injury mortality after paramedic rapid sequence intubation. J Trauma. 2005;59:486–90.

Objective

The study objective was to continue to explore a hypothesis, suggested by the authors' previous work, that hyperventilation was responsible for worsened outcome in prehospital head-injured patients undergoing ETI.

Methods

Study Design

The study assessed data from the San Diego County Trauma Registry and the San Diego RSI Trial; a matching approach was used to generate a nonintubated (historical) cohort for outcomes comparison against the prospectively generated ETI cohort. A number of demographic, injury (e.g., mechanism, ISS, AIS scores for various systems), treatment, and outcome variables were collected; one of the major independent variables tracked was air versus ground transport mode.

Setting

The study was conducted in California, with interventions being provided by two ground paramedics responding to all major trauma; patients were either transported by those ground units or HEMS (which had variable staffing comprising flight nurses, emergency medicine resident physicians, and paramedics). Patients were cared for at five adult Level I or II trauma centers.

Time Frame

Study patients were consecutive transports occurring between 1998 and 2002.

Patients

Subjects included 352 intubated (RSI trial) patients and 704 hand-matched nonintubated controls; all patients were transferred directly from trauma scenes to trauma centers. The ETI group study patients were those with severe head injuries (GCS 3–8), who could not be intubated without RSI; patients were excluded if they died in the field or within 30 minutes of ED arrival.

Analysis

Multivariate logistic and also least squares regression analyses incorporated myriad demographic, injury, treatment, and outcome parameters. Odds ratios were calculated with stratification to adjust for various study variables.

Results

The authors' overall results were adjusted for ISS, head and other systems AIS scores, age, sex, injury mechanism, blood pressure, prehospital GCS, and type of head injury. Results pertinent to RSI are reported in detail in the article. More relevant to this review was the finding that, in least squares regression analysis, HEMS compared to ground transport was found to be a significant ($p = 0.011$) predictor of survival. In logistic regression, HEMS also was found to be associated with

a significant ($p = 0.011$) predictor of survival. In lofistic regression, Hems also was found to be associated with a significant ($p < .05$) improvement in "good outcome" (discharge to home or rehab or similar facilit) with an odds ratio of 0.6 and 95% CI of 0.3–1.0.

Authors' Conclusions

HEMS transport was associated with improved outcomes, likely due to the less frequent incidence of inadvertent hyperventilation among RSI trial patients transported by air.

Commentary

This study's methodology was superb, and the details of the matching provided in the manuscript serve as a model for conducting such a study design. Importantly, the authors had included transport mode in their a priori end point definitions. This increases the impact of their results and strengthens the case that—at least in San Diego—HEMS transport improves head injury outcome and that it does so in part through some mechanism related to airway and ventilatory management even when the initial ETI is performed by ground units.

Neonatal

- Berge SD, Berg-Utby C, Skogvoll E. Helicopter transport of sick neonates: a 14-year population-based study. Acta Anesthesiol Scand. 2005;49:999–1003.

Objective

The study's goal was to describe HEMS transport and outcome (as measured by survival and also by predefined physiological parameters) of neonates in central Norway.

Methods

Study Design

Retrospective, population-based analysis of consecutive HEMS neonatal transports.

Setting

The study was conducted in central Norway, in an area served by three HEMS bases and four hospitals with an overall service area of nearly 400,000 people. The HEMS services were staffed by anesthesiologists and paramedics.

Time Frame

Study patients were transported between 1988 and 2001.

Patients

Subjects were 252 neonates undergoing air transport.

Analysis

The authors' analysis was primarily descriptive; there was no formal statistical comparison either against a control group (for mortality assessment done at 1-year post-transport) or between pretransport versus intratransport physiological variables (presence or absence of appropriate oxygenation, ventilation, and circulation) as assigned by the authors, using a priori definitions, on retrospective panel review. The authors defined as "life-saving interventions" those interventions provided by the HEMS crews, which were outside the scope of the referring agency (e.g., intubation, ventilation, and fluid administration).

Results

The authors found that there were no transport-related deaths, that HEMS crews were able to respond quickly and effectively, and that lifesaving assistance was provided in 11 transports. Compared to the proportions of neonates with adequate ventilation, oxygenation, or circulation in the pre-transport phase (43%, 59%, and 84%, respectively), the corresponding proportions were all higher for the intratransport phase (75%, 87%, and 91%); however, no formal statistical analysis was performed. Overall mortality (which was 12%) was described by the authors as consistent with that achieved in other sections of Norway in which neonates were delivered at higher-level centers (i.e., didn't need to undergo transport).

Authors' Conclusions

HEMS services provide a rapid means for effective, sometimes lifesaving transport of neonates in the service area studied.

Commentary

This was a "panel review" type study, in which assignation of benefit was retrospectively executed by those who may or may not have had subjective biases about HEMS utility. The study would have been improved by formal statistical comparison of the pretransport versus intratransport physiological parameters of oxygenation, ventilation, and circulation (these variables were quite reasonably defined and spelled out in detail in the paper). However, the article did clearly suggest that HEMS crew arrival was associated with performance of advanced interventions. Furthermore, those advanced clinical interventions seemed to correspond to improved physiological parameters, and the overall result was a transport-cohort mortality as good as

that of nontransported neonates. Despite the significant weaknesses inherent to the study's retrospective review design and lack of rigorous analysis, this population-based study does suggest that in central Norway at least, there is probably some benefit to HEMS use for neonatal transport.

- Hon K, Olsen H, Totapally B, Leung TF. Air versus ground transportation of artificially ventilated neonates: comparative differences in selected cardiopulmonary parameters. Pediatr Emerg Care. 2006;22:107–12.

Objective

The study's goal was to assess whether air, compared to ground transport, was associated with higher risk of physiological deterioration as assessed by capnometry and by need for intratransport cardiopulmonary interventions.

Methods

Study Design

Retrospective analysis of consecutive air (almost all HEMS) and ground neonatal transports.

Setting

The study was conducted out of Miami Children's Hospital. The air and ground transport services were staffed by the same providers, with the team comprising pediatric intensive care transport nurses, senior pediatric residents, pediatric intensive care unit fellows, and paramedics.

Time Frame

Study patients were transported during 2001.

Patients

Subjects were 75 intubated neonates undergoing transport; 43 patients were transported by ground vehicle, 29 by helicopter, and 3 by fixed-wing aircraft.

Analysis

The primary analyses assessed for association between transport mode and risk of need for intratransport cardiopulmonary interventions (e.g., ventilator adjustments, changes in pressor infusions). Air and ground patients were also compared for likelihood of hypo- or hypercapnia as assessed by initial receiving hospital blood gas.

Results

The authors found that there were no transport-related deaths and that air transport was not associated with increased risk of hypo- or hypercapnia on receiving hospital arrival. Furthermore, although need for intratransport cardiopulmonary interventions was frequent, the indication for such interventions was no different in air transported patients (14 of 32) compared to those transported by ground (25 of 43).

Authors' Conclusions

Air transport was unassociated with increased risk of physiological deterioration as assessed by need for interventions or as indicated by receiving center assessment of carbon dioxide tension.

Commentary

Though limited by retrospective design and incomplete assessment for acuity differences in air versus ground transport cohorts, this article's primary message is that advantages of speed and minimized out-of-hospital time accrued by air transport are not associated with physiological costs. It appears that ground transport was used for close-in patients (median ground transport return time of 25 minutes compared to rotor-wing median of 35 minutes, and interquartile ranges were narrow for both groups). Because the same transport team cared for all patients, confounding by care providers was not an issue. Thus, in this most unstable of patient populations, an apparently logistically based (and seemingly wise) use of air transport resources was found to be unassociated with risk of physiological deterioration.

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