Trauma helicopter emergency medical services transport: Annotated review of ...
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ANNOTATED REVIEW

TRAUMA HELICOPTER EMERGENCY MEDICAL SERVICES TRANSPORT:

ANNOTATED REVIEW OF SELECTED OUTCOMES-RELATED LITERATURE

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ABSTRACT

Based on its roots in military air evacuation, helicopter emergency medical services (HEMS) has always been emphasized as a tool for trauma transportation. Despite much discussion regarding resource allocation for HEMS, a literature search found little recent systematic review of pertinent studies. As HEMS utilization is subject to increased scrutiny in a health care dollar-conscious environment, it was felt that a compendium of available outcomes-related literature could assist those assessing utility of HEMS trauma transport. The current study utilized a Medline search to identify outcomes studies relative to HEMS trauma transport. The goal of this review is to provide a useful resource for those interested in pursuing systematic review of the HEMS trauma outcomes literature. The primary purpose of the review is bibliographic, but there is editorial comment after each paper's summary. The initial article in this two-part series focused on HEMS outcomes literature covering noninjured patients as well as papers assessing outcome in mixed trauma–nontrauma HEMS study groups. **Key words:** HEMS; helicopter transport; outcomes; trauma; scene; interfacility.

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After use of helicopters played an important role in the military trauma care systems of the Korean and Vietnam wars, U.S. civilian helicopter emergency medical services (HEMS) was born in the 1970s. Given the trauma-related nature of helicopter transport's military roots, early programs understandably focused on evacuation of injured patients to trauma centers. HEMS programs have evolved to play a role in nontrauma transport, as outlined by the first installment of this two-part series,[1] but transport of injured patients remains a primary goal of most HEMS programs.

Despite the frequency of trauma HEMS transport, a literature search failed to identify comprehensive reviews encapsulating extant HEMS trauma outcomes research. Therefore, it was decided to prepare an annotated bibliography on the subject, with the primary goal of providing a reference for those interested in assessing available information in this subject area. An additional goal of providing commentary on the summarized literature was of secondary importance; this commentary is included primarily to aid in placing the summarized articles in perspective and is not intended to provide detailed review or judgment regarding the papers.

METHODS

A computerized literature search was performed. The search database was the National Library of Medicine's Medline (online *Index Medicus*), extending from January 1980 through June 2000. It was decided to limit the review's focus to English-language journals indexed in Medline/*Index Medicus*. This approach's inevitable exclusion of worthy papers was accepted only after much consideration, but two principles were overriding: 1) scientific quality is a major tenet upon which journal indexing is based, and thus use of indexed journals established a concrete, objective, scientific quality threshold for study inclusion in this review; and 2) nonindexed and foreign-language journals are less likely to be readily available to the intended readership of this review, a primary intent of which is to serve as a guide directing interested parties to the reviewed studies. It is worth emphasis that some excellent and relevant papers are to be found in both the nonindexed and in the non-English literature; their exclusion from this review is not intended in any way to imply inferiority of these papers or the journals in which they appear.

Utilization of the search term *helicopter* returned 834 citations. The terms *rotorcraft* and *rotorwing* returned nine citations, some of which were not included in the *helicopter* search. Next, the following MeSH headings were uti-

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lized: *aircraft, transportation of patients, air ambulances, aviation, emergency medical services,* and *aerospace medicine.* Content of all papers was reviewed by title and/or abstract review. The criterion for a paper's inclusion in this review was that the paper address, either as its primary goal or as a secondary goal, potential outcome improvement associated with HEMS trauma transport. Only the parts of a paper pertinent to outcomes analysis are reviewed here. Because of their frequent citation or methodologic issues, some papers were felt to warrant more attention than others. Since the process of article selection and review was subjective, the authors do not claim the current bibliography comprehensive; it is their intention that it contain most of the literature that would be of aid to future researchers.

The papers included in the review are categorized into three areas. Within each category, papers are listed chronologically starting from the earliest publication year. The first category, *Scene,* assesses studies of HEMS use in transporting patients directly from trauma scenes. The second category, *Interfacility,* is comprised of papers addressing interfacility transport only. Papers in the third category, *Scene and Interfacility,* had patient populations that encompassed both scene and interfacility transports.

Trauma outcomes analysis is different from nontrauma outcomes analysis in that there are many scores [e.g., Glasgow Coma Score (GCS), Trauma Score (TS), Injury Severity Score (ISS)] that can be used to stratify patient acuity. The reader is expected to be familiar with most of these scales, but one related subject is sufficiently complex and frequently used to warrant brief explanation here. The TRISS method, explained in detail elsewhere,[2] plays a role in many of the studies noted below. TRISS incorporates physiologic (TS), anatomic (ISS), mechanism (blunt vs. penetrating), and age (55 years as dichotomous cutoff) covariates into a logistic regression model with mortality as the dependent variable. Predicted mortality, calculated using a multivariate logistic regression model [with β coefficients from a large Multiple Trauma Outcome Study (MTOS) database], can then be compared with actual mortality. The "Z" statistic can be used to assess overall mortality difference between the MTOS population and the study cohort. Preferably, the first step in using TRISS for outcomes analysis is to ensure that the study group's injury acuity distribution is sufficiently similar to that of MTOS population to enable use of the MTOS-derived regression coefficients. This is performed by calculating an "M" statistic. If the "M" statistic denotes appropriateness of TRISS utilization, a "W" statistic can be calculated, which estimates the number of lives saved per 100 transports. In cases where further stratification is necessary or if the "M" statistic is too low (<0.88) for TRISS analysis, adjusted or standardized "W" statistics can be calculated. While many trauma papers use TRISS's MTOS population to provide a "control" group, the optimal approach is to perform simultaneous TRISS analysis on HEMS and ground transported patients. Such a study design provides relatively strong evidence of HEMS-associated benefit if HEMS, but not ground transport, patient mortality is less than TRISS-predicted.

As a review article, this is a descriptive paper. However, when in some cases statistical calculations were performed, the software package used was Intercooled STATA 7.0 for Windows (Stata Corporation,, College Station, TX).

REVIEW

SCENE

• Baxt WG, Moody P. The impact of rotorcraft aeromedical emergency care service on trauma mortality. JAMA. 1983;249:3047-51.

Objective The study's objective was to assess the impact of scene HEMS transport on blunt trauma mortality.

Methods

Study Design Retrospective TRISS-based study.

Setting The study HEMS program, staffed by a nurse/physician (RN/MD) crew, was based at the University of California at San Diego, the Level I center to which all of the study's HEMS and ground patients were transported. Most (93%) of the ground transport group had advanced life support (ALS)-level initial attendants, whereas most (68%) of the HEMS group were initially attended by basic life support (BLS)-level emergency medical technicians (EMTs).

Time Frame Study patients were transported over an undisclosed 30-month period.

Patients Patients were 150 consecutive HEMS and 150 consecutive ground blunt trauma scene transports.

Analysis Actual vs. predicted survival was assessed by utilizing TRISS methodology.

Results There were no differences between HEMS, ground, and the index (MTOS) groups in terms of injury severity distribution. While ground-transported patients died at a rate statistically similar to that predicted, HEMS mortality was 52% lower than predicted. Lower mortality for HEMS patients was significantly different ($p < 0.001$) from both TRISS-predicted mortality and mortality in the ground cohort. Time between incident to trauma center arrival was 35 minutes for the ground group (most of whom were transported from shorter distances) and 58 minutes for the HEMS group.

Authors' Conclusions HEMS scene transport reduces blunt trauma mortality.

Commentary This was the first analytic attempt to determine whether HEMS was associated with mortality benefit. The incorporation of a ground control group is a particular strength of this paper, though limited ground unit capabilities (e.g., use of esophageal obturator airways) limit the study's current applicability.

• Fischer RP, Flynn TC, Miller PW, Duke JH. Urban helicopter response to the scene of injury. J Trauma. 1984;24:946-51.

Objective The study's objective was to review and characterize HEMS scene missions.

Methods

Study Design Retrospective descriptive study.

Setting The study program, LifeFlight, utilized an RN/MD crew and transported patients to Hermann Hospital, a Level I center in Houston.

Time Frame Study patients were transported during 1981.

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Patients Patients were 577 trauma scene patients with both blunt (n = 466) and penetrating (n = 111) mechanisms.
Analysis The primary analysis was descriptive.
Results Overall mortality was 24% for transported patients. Advanced scene treatments were routinely initiated for patients with severe head injuries.
Authors' Conclusions Trauma scene flights with a skilled crew provide a valuable medical service for large congested areas such as Houston.
Commentary This study's descriptive nature was typical of many contemporary papers. The authors' conclusion that HEMS may be of benefit in traffic-congested metropolitan areas, while not proved by their data, provided a direction for further investigation.

• Baxt WG, Moody P, Cleveland HC, et al. Hospital-based rotorcraft aeromedical emergency care services and trauma mortality: a multicenter study. Ann Emerg Med. 1985;14:859-64.
Objective The study's objective was to review scene HEMS transport effects on blunt trauma mortality.
Methods
Study Design Retrospective TRISS-based study.
Setting The seven study HEMS programs were based at the University of California at San Diego, St. Anthony's Hospital in Denver, Hermann Hospital in Houston, Allegheny Hospital in Pittsburgh, Geisinger Medical Center in Danville (Pennsylvania), Methodist Hospital in Indianapolis, and Valley Hospital in Las Vegas. The services' crew configurations were variable, ranging from single RN to RN/MD crews.
Time Frame Study patients were transported between March 1981 and March 1983.
Patients Patients were 1,273 blunt trauma scene transports by the participating HEMS services.
Analysis Actual vs. predicted survival was assessed by utilizing TRISS methodology.
Results In all seven HEMS services, there was a reduction in mortality vs. that predicted by TRISS; the difference reached statistical significance in five of seven programs. Overall, there was a 21% mortality reduction associated with HEMS use.
Authors' Conclusions HEMS scene transport may reduce blunt trauma mortality.
Commentary The finding that all seven HEMS services demonstrated a mortality reduction, with the difference statistically significant in five of seven, was compelling evidence that the study patients suffered fewer trauma deaths than the number predicted by TRISS. This conclusion is strengthened by the fact that the MTOS data had only recently been published, and therefore the TRISS analysis was contemporary to MTOS. It is, therefore, difficult to dispute the validity of this study's TRISS results. What is disputable, in the absence of a concurrent ground transport "control" group with its own TRISS analysis, is whether the mortality reduction was due to HEMS services or some other non-HEMS factor.

• Baxt WG, Moody P. The impact of advanced prehospital emergency care on the mortality of severely brain-injured patients. J Trauma. 1987;27:365-9.
Objective The study's objective was to assess whether HEMS scene transport of severely brain injured patients was associated with improved mortality and morbidity.
Methods
Study Design Retrospective cohort study.
Setting The study HEMS program, based at the University of California at San Diego, utilized an RN/MD crew and transported study patients to the UCSD Level I center. Ground ALS patients were transported by crews using esophageal obturator airways as their highest level of airway management.
Time Frame Study patients were transported over an unspecified 50-month period.
Patients Patients were 128 consecutive blunt trauma scene HEMS or ALS ground transports with scene vital signs and GCS < 9.
Analysis Survival rates in HEMS vs. ground patients were compared after univariate analysis confirmed between-groups similarity in central nervous system (CNS) lesion distribution and GCS scores.
Results The mortality of ground-transported patients (31%) was in line with that expected by the authors based upon contemporary literature, but HEMS patient mortality was significantly lower (40%, $p < 0.001$). Patients in the HEMS group also had significantly better Glasgow Outcome Scores than the ground group ($p < 0.05$).
Authors' Conclusions As compared with ground transport, HEMS is associated with both mortality reduction and improvement in Glasgow Outcome Score in patients with severe brain injuries.
Commentary Use of esophageal obturator airways by the ground units gives HEMS patients something of a head start on mortality improvement. Other differences between HEMS and ground groups (e.g., HEMS patients' management by BLS for a mean 25 minutes prior to helicopter arrival) rendered straightforward comparison difficult. As applied during the study era, the paper makes a strong argument for HEMS-associated mortality improvement, and is one of the few papers in the HEMS literature that addresses and shows benefit in morbidity. With respect to current interpretation of the results, unless they are replicated in a setting in which HEMS and ground units have similar capabilities, this study may be more of an argument for a high level of prehospital care than it is for HEMS.

• Baxt WG, Moody P. The impact of a physician as part of the aeromedical prehospital team in patients with blunt trauma. JAMA. 1987;257:3246-50.
Objective The study's primary objective was to review the impact of adding a physician to a HEMS crew; as a part of the study methods, the authors assessed actual vs. predicted outcomes in two groups of HEMS patients.
Methods
Study Design Prospective TRISS-based study.
Setting The study HEMS program, based at the Level I University of California at San Diego Medical Center, utilized two aircraft: one was staffed by an RN/EMT–paramedic (EMT-P) crew and the other by an RN/MD crew. Dispatching of helicopters to trauma scenes was driven by flight rotation or geographical considerations and was not related to crew configuration.

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Time Frame Study patients were transported over an undisclosed 24-month period.
Patients Patients were 574 consecutive blunt trauma scene transports, 316 of whom were treated by the RN/MD crew and 258 of whom were treated by the RN/EMT-P crew.
Analysis Actual vs. predicted survival was assessed with TRISS methodology.
Results In the RN/EMT-P transports, predicted and actual mortalities were statistically similar, but mortality in the RN/MD crew was lower than that of the RN/EMT-P crew and also 35% lower than that predicted by TRISS ($p < 0.05$ for both comparisons). Blinded review of dying patients' charts revealed no errors by the RN/MD crew, whereas there were multiple instances where the RN/EMT-P crew failed to follow protocols (e.g., failed or esophageal intubation, failure to provide chest decompression).
Authors' Conclusions Physician-staffed HEMS service was associated with a significant mortality reduction in scene blunt trauma transports, but a mortality reduction was not seen in RN/EMT-P HEMS transports. The outcomes differences between RN/MD and RN/EMT-P crews are due to less frequent and less successful performance of indicated interventions.
Commentary Given the fact that some prehospital interventions were outside the paramedics' scope of practice, the cards may have been stacked against the RN/EMT-P crew who effectively had half the effective manpower when it came to performing the restricted procedures. The currently expanded scope of practice of nearly all nonphysician HEMS crews would appear to support the authors' contention that the psychomotor and judgment skills exhibited by the RN/MD crew are teachable to a nonphysician crew. The paper's finding relevant to this review is that once again, TRISS analysis demonstrates a significant mortality reduction in a set of HEMS patients attended by a highly qualified crew.

• Schiller WR, Knox R, Zinnecker H, et al. Effect of helicopter transport of trauma victims on survival in an urban trauma center. J Trauma. 1988;28:1127-34.
Objective The study objective was to determine whether HEMS scene transport was associated with mortality improvement in an urban setting with a well-developed EMS system.
Methods
Study Design Retrospective cohort study.
Setting The study was conducted at St. Joseph's Hospital in Phoenix, Arizona. There was no information given on level of care capabilities of HEMS and ground EMS services.
Time Frame Study patients were transported between 1983 and 1986.
Patients The study group was comprised of blunt trauma patients with ISSs between 20 and 40; patients were separated into two groups (ISS 20–29 and ISS 30–39).
Analysis Statistical assessment of outcome was performed by analyzing HEMS and ground survival in each of the two ISS groups. Other parameters of HEMS and ground patients were also compared to assess similarity between groups.
Results Overall, HEMS mortality was significantly higher than that of the ground-transported group, but there were significant differences between HEMS and ground patients. The ground patients were mostly (92%) transported from within Phoenix city limits, whereas most (70%) of the HEMS patients were transported from outside the city. When patients transported from within the city limits were assessed, HEMS patients had significantly lower GCSs than ground patients (8.7 vs. 10.2).
Authors' Conclusions HEMS is not associated with mortality improvement in the setting of urban trauma with a well-developed emergency medical services system.
Commentary More information on the capabilities of ground and HEMS crews would have aided in interpretation of this paper's results, but other considerations render this otherwise critical issue nearly moot. Specifically, the differing urban vs. suburban distribution of HEMS and ground patients is not inherently problematic (this casemix is found in the UCSD studies), but there is strong suggestion of linked confounding due to GCSs' varying with patient location. The use of ISS-grouped crude mortality analysis is not without intrinsic appeal, as it is more straightforward than multivariate techniques, but nonadjusted analyses engender much higher potential for residual confounding. The authors' conclusion, that HEMS has little mortality impact when used within a city with short ALS response and transport times, is very sensible. However, this paper no more proves its point than a 1984 study by Fischer et al. (see above, J Trauma. 1984), which reached an opposite conclusion about use of HEMS in another, presumably more congested, urban setting.

• Schwartz RJ, Jacobs LM, Juda RJ. A comparison of ground paramedics and aeromedical treatment of severe blunt trauma patients. Conn Med. 1990;54:660-2.
Objective The study's objective was to determine the relative contributions of prehospital time and transport mode towards mortality improvement.
Methods
Study Design Retrospective cohort study.
Setting The study HEMS program, LifeStar, was staffed by a respiratory therapist and a second crew member who was qualified as both nurse and paramedic; transports were performed within a 150-mile radius of Hartford Hospital in Connecticut.
Time Frame Patient were transported between July 1987 and July 1988.
Patients Study patients were consecutive HEMS (n = 93) and ground (n = 33) paramedic-level transports from trauma scenes to the study center.
Analysis Actual vs. predicted survival was assessed with TRISS. Prehospital times were also assessed.
Results By TRISS Z statistics, HEMS transport was associated with a significant mortality reduction and ground transport with a mortality increase as compared with MTOS. Prehospital times were similar. There were indications of improved care (e.g., higher intubation rates) in the HEMS group as compared with ground paramedic-transported patients.
Authors' Conclusions Given similar prehospital times, the explanation for mortality improvement was attributed to improved care provided by HEMS crews.

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Commentary This was an early TRISS study, which enrolled fewer patients and had slightly less statistical rigor (e.g., lack of M statistic demonstration of appropriateness of MTOS comparison) than some others in this review. The use of a ground transport group as control helps to offset the methodologic shortcomings, and the study's findings were consistent with a later analysis from the same center (see below, Jacobs et al., Conn Med. 1999), which included patients from this study in its larger ten-year cohort.

• Hamman BL, Cue JI, Miller FB, et al. Helicopter transport of trauma victims: does a physician make a difference? J Trauma. 1991;31:490-4.

Objective The study's primary objective was to review the impact of a physician crew member on HEMS-associated trauma outcome improvement in scene trauma patients.

Methods

Study Design Retrospective TRISS-based study.

Setting The study HEMS program transported patients to the Humana Hospital in Louisville, Kentucky.

Time Frame The study was conducted over two ten-month periods: during 1985, during which time a physician was part of the HEMS crew, and a second period during 1987 when HEMS crew consisted of a nurse and paramedic.

Patients Study patients were 145 consecutive adult HEMS trauma scene transports occurring over the two study periods.

Analysis Actual vs. predicted survival was assessed with TRISS methodology, with MTOS as the "control" group.

Results The M statistic for both HEMS cohorts was 0.87, which was slightly less than the standard of 0.88 generally required for validation of TRISS use for a population. The authors proceeded to report that TRISS Z statistics were positive for both HEMS groups, with a statistically significant 30% reduction in the physician-crew HEMS group and a significant 47% mortality reduction in the non-physician HEMS crew.

Authors' Conclusions Using experienced nurses and paramedics, a nonphysician HEMS crew can provide a high level of prehospital care. Transport by both physician and nonphysician HEMS crews was associated with improved survival over that predicted.

Commentary Like some other papers in this review, the main focus of this study was on HEMS crew composition rather than outcome. This means that the TRISS-based outcomes analysis carries less weight, especially in light of the borderline M statistic values. In fact, others who have calculated an M statistic of 0.87 have concluded that TRISS analysis was inappropriate in their cohort (see below, Schmidt et al., J Trauma. 1992). The fact remains that this study's MTOS matching is better than that of other papers (e.g., the Nicholl study: see below, Nicholl et al., BMJ. 1995) commonly cited as demonstrating lack of HEMS efficacy, so this study could reasonably be added to the pile of TRISS analyses suggesting mortality benefit from HEMS trauma scene use.

• Schmidt U, Frame SB, Nerlich ML, et al. On-scene helicopter transport of patients with multiple injuries—comparison of a German and an American system. J Trauma. 1992;33:548-55.

Objective The study's primary objective was to assess outcomes differences associated with use of HEMS crews with differing capabilities in Germany and the United States; as a secondary goal, the study assessed outcomes of each HEMS program vs. predicted mortality.

Methods

Study Design Retrospective TRISS-based study.

Setting U.S. transports were conducted by the Lifestar HEMS program, with an RN/EMT-P crew, which transported patients to the University of Tennessee Medical Center in Knoxville. U.S. HEMS crews did not have access to analgesia, sedation, or neuromuscular blockade. German patients were transported by Christoph-4, with an MD/EMT-P crew, to the Hannover School of Medicine.

Time Frame Study patients were transported during 1988 and 1989.

Patients 186 U.S. HEMS scene patients (89.2% blunt) and 221 German HEMS scene patients (100% blunt) comprised the study groups.

Analysis Actual vs. predicted survival was assessed with TRISS analysis.

Results There were six unexpected survivors for the U.S. HEMS system and nine for the German system. The M statistic demonstrated appropriateness of TRISS outcomes analysis for the German, but not the U.S., cohort (the U.S. group's M statistic was 0.87). W statistic calculations yielded an estimate of 14 lives saved per 1,000 German HEMS scene transports. German HEMS patients were more likely (37% vs. 13%) to be intubated, were more likely to undergo needle thoracostomy, and received twice the intravenous (IV) fluid volume as compared with U.S. HEMS patients.

Authors' Conclusions The German HEMS system was associated with outcome improvement as assessed by TRISS, but the (smaller and not significant) outcome improvement associated with U.S. HEMS transport could not be properly assessed with TRISS. The improved outcome in Germany was probably associated with more aggressive prehospital therapy.

Commentary The main purpose of this very well-conducted, methodologically rigorous study was to compare the two countries' HEMS programs to see whether differing flight crew capabilities were associated with mortality difference. The authors concluded that aggressive prehospital therapy, regardless of who provides such therapy, is a critical component of HEMS-associated outcomes improvement. Given the fact that capabilities of virtually all U.S. HEMS crews now exceed those of the study era, and many (if not most) provide neuromuscular blockade, the primary import of this study ten years later is that it is yet another TRISS analysis demonstrating mortality improvement for scene trauma flights by high-level HEMS crews.

• Cameron PA, Flett K, Kaan E, Atkin C, Dziukas L. Helicopter retrieval of primary trauma patients by a paramedic helicopter service. Aust N Z J Surg. 1993;63: 790-7.

Objective The study's objective was to evaluate the first years of a HEMS service's scene trauma operations.

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Methods

Study Design Retrospective TRISS-based study that also incorporated panel assessment of preventability of deaths.

Setting The study was conducted in Australia at the Alfred Hospital in Melbourne. HEMS patients were transported by the Metropolitan Helicopter Ambulance Service, with a single EMT-P medical crew member and two pilots.

Time Frame Study patients were transported over a 3.5-year period commencing July 1986.

Patients Patients were consecutive scene trauma patients transported by the HEMS service.

Analysis The study's primary analysis was descriptive, and included assessment of preventability of death. Comparison of actual vs. predicted mortalities was made using TRISS methodology.

Results Injury acuity was high, with a median ISS of 22. Two cases were judged as possibly preventable deaths: one patient who died of a tension pneumothorax without needle decompression and one patient who was not intubated. By the TRISS Z statistic, the overall survival of 14% was similar to the predicted mortality of 17%.

Authors' Conclusions Overall, prehospital treatment of trauma by HEMS crews was good, except for low intubation rates.

Commentary The fact that patients died at a rate no better than predicted is not surprising given the low (58%) intubation rate in patients with GCS of 3–7. Since most HEMS services' intubation rates for this group would be expected to be 90–100%, the negative results of this Australian study are not easily translated to the United States.

• Malacrida RL, Anselmi LC, Genoni M, Bogen M, Suter PM. Helicopter mountain rescue of patients with head injury and/or multiple injuries in southern Switzerland 1980–1990. Injury. 1993;24:451-3.

Objective The study's objective was to review the impact of a HEMS service on trauma outcome in geographically isolated patients.

Methods

Study Design Retrospective cohort study.

Setting The study HEMS program, Swiss Air Rescue (REGA), was winch-equipped and physician-staffed and responded to trauma scenes in southern Switzerland.

Time Frame Study patients were transported between 1980 and 1990.

Patients Study patients were 57 consecutive patients with head injuries or multiple trauma who required HEMS winch rescue; this group represented 11.5% of the overall HEMS winch-rescue population during the study period. Most patients (55%) were mountaineers, with aviation accidents and mountain workers comprising another 20%. Acuity was assessed with the National Advisory Committee for Aeronautics (NACA) Gravity Index, which in 91% of patients was 4 or more (death possible or probable).

Analysis Analysis was descriptive. Results were informally compared with other reported case series in the literature.

Results The patients were of high acuity as assessed by GCS, NACA, and computed tomography (CT) scan results. The mortality rate was 12%, 12% had mild neurologic residua, and none of the survivors had serious neurologic disability.

Authors' Conclusions Outcome in study patients was similar to that of other case series of similarly injured patients cared for at trauma centers. For injured patients in areas where access by other means is prolonged or impossible, rescue by a HEMS crew providing on-scene treatment can improve prognosis.

Commentary Most would agree that if HEMS is helpful in any situation, it would be in the that of geographical isolation, but it is not easy for a study to directly address this issue. This paper is limited by the descriptive nature of its analysis and the relatively small number of patients. Additionally, the authors' conclusions—that HEMS must have been beneficial since isolated patients had mortality similar to that of other patients—are tenuous. However, the results do provide a basis for support of the common-sense idea that HEMS may offer benefit for otherwise inaccessible patients.

• Nardi G, Massarutti D, Muzzi R, et al. Impact of emergency medical helicopter service on mortality for trauma in north-east Italy: a regional prospective audit. Eur J Emerg Med. 1994;1:69-77.

Objective The study's objective was to review the blunt trauma mortality impact of scene HEMS stabilization and trauma center transport, as compared with transport by ground ambulance units to either local hospitals or trauma centers.

Methods

Study Design Prospective cohort study.

Setting The study was conducted in a mostly rural area of northeast Italy, which is served by 12 local hospitals and four trauma centers. A single HEMS service, staffed by an RN/MD crew, was triaged to trauma scenes based on mechanism-of-injury protocols.

Time Frame Study patients were transported between August 1992 and February 1993.

Patients Blunt trauma patients who were alive upon arrival of HEMS or ground units to trauma scenes were included in the study if their ISS was over 15. Patients were grouped into three groups: HEMS transports to trauma center, ground transports to trauma center, and ground transports to local hospitals (with subsequent ground or air transfer to trauma centers).

Analysis As mean ages and ISS scores in each of the three groups were similar (35, 33, and 36), univariate mortality analysis was performed.

Results Patients in the HEMS group were more likely to be intubated (81%) than patients in either of the ground transport groups (2% and 0%). HEMS patients were the only group who received scene thoracic drainage (12%) and received more IV fluid resuscitation. Mortality was significantly lower in the HEMS group (12%) than in either ground transport group (38% and 32%).

Authors' Conclusions HEMS crew scene stabilization and transport were associated with a threefold reduction in mortality as compared with ground transport. Similar

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mortality rates in the two ground transport groups suggest that HEMS care, rather than direct transport from scenes to trauma centers, was responsible for the improved outcome in the HEMS group.

Commentary Like some other studies in this review, this paper clearly demonstrates that HEMS improves mortality when HEMS crew capabilities are more advanced than medical care provided by ground transport personnel. In rural regions such as the study area, the HEMS program may be the most efficient means to get advanced care to the patient.

• Nicholl JP, Brazier JE, Snooks HA. Effects of London helicopter emergency medical service on survival after trauma. BMJ. 1995;311:217-22.

Objective The study's objective was to assess the impact of HEMS on trauma outcomes in scene patients.

Methods

Study Design Prospective cohort study using TRISS methodology for outcomes analysis.

Setting The study was conducted in the London area, with patients transported to 20 regional hospitals, one of which—the Royal London Hospital (RLH)—has facilities similar to those of a U.S. Level I center. The HEMS service, London HEMS, is staffed by an MD/EMT-P. Ground transports in the control group were crewed by EMT-Ps.

Time Frame Study patients were transported between August 1991 and July 1993.

Patients Study patients were scene trauma patients whom HEMS or ground units transported to one of 20 hospitals. To minimize the impact of HEMS patients' being preferentially treated at the RLH (which had a higher level of trauma care), only one in three RLH HEMS transports were included. HEMS patients were comprised of three groups in which HEMS crews were in attendance at trauma scenes: patients transported by helicopter, patients transported by ground with HEMS crews in attendance, and patients transported by ground without HEMS crews in attendance. The ground transport group was comprised of patients transported by intubation-capable EMT-P crews to the study hospitals during the study period.

Analysis Mortality was assessed at six months post-trauma, and included patients dying of non-blunt trauma entities such as smoke inhalation, myocardial infarction, and death occurring "in old people after admission to hospital with minor injuries." TRISS analysis was used, though there was no M statistic reported to confirm the appropriateness of MTOS use. The authors used an inverse reweighting scheme to attempt to control for the fact that most HEMS trauma center (RLH) transports were excluded.

Results Data sufficient for TRISS analysis was available for 87% of HEMS cases and 64% of ground cases. Overall, HEMS patients had a mortality which exceeded TRISS-predicted by 15.6%, while ground patient mortality exceeded predicted by 2.4%. Approximately 13 lives (95% confidence interval –5 to 39) were saved annually by use of HEMS in the area studied.

Authors' Conclusions Over the entire HEMS caseload, there was no evidence of reduced mortality.

Commentary This paper began by looking at a subset of patients assessed by Younge et al. (see below, J Trauma. 1997), which demonstrated improved mortality in 632 HEMS scene transports to the RLH over a four-year period that encompassed the two-year period of this study. The unusual exclusion criteria (e.g., discarding most HEMS trauma center transports), differing data availability for HEMS and ground patients, inclusion of three groups of "HEMS" patients (including some transported by ground), and odd outcomes assessment are among the paper's serious methodologic flaws. The validity of the study results is further cast into question when one considers that in a better-designed study of an overlapping patient group, Younge et al. found a mortality benefit associated with HEMS transport to the RLH; there is no external validity (to the United States, at least) of this study's analysis of HEMS transport to non-trauma centers. Perhaps as important as any other criticism of this study is its lack of reporting of an M statistic in light of Younge's demonstration, in an overlapping cohort, of an M statistic too low to allow standard TRISS analysis. Despite the high frequency with which this paper is cited, few, if any, conclusions can be drawn from it.

• Brazier J, Nicholl J, Snooks H. The cost and effectiveness of the London helicopter emergency medical service. J Health Serv Res Policy. 1996;1:232-7.

Objective The study's objective was to assess the impact of HEMS on disability outcomes in patients surviving trauma.

Methods

Study Design Prospective cohort study of medical records with survey instrument obtained for some patients.

Setting The study was conducted in the London area, with patients transported to 20 regional hospitals, one of which [the Royal London Hospital (RLH)] has facilities similar to those of a U.S. Level I center. The HEMS service, London HEMS, is staffed by an MD/EMT-P crew.

Time Frame Study patients were transported between August 1991 and August 1993.

Patients Study patients were scene trauma patients whom HEMS or ground units transported to one of 20 hospitals. To minimize the impact of HEMS patients' being preferentially treated at the RLH (which had a higher level of trauma care), only one in three HEMS transports to the RLH were included. HEMS patients were comprised of three groups in which HEMS crews were in attendance at trauma scenes: patients transported by helicopter, patients transported by ground with HEMS crews in attendance, and patients transported by ground without HEMS crews in attendance. The ground transport group was comprised of patients transported by paramedic (intubation-capable) crews to the study hospitals during the study period.

Analysis Scores on the disability scales were assessed using analytic methods which adjusted for possibly confounding factors (e.g. ISS, GCS, RTS).

Results Response rates for morbidity analysis were 73% of those approached for HEMS patients, and 63% for ground patients. There was no significant difference

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between HEMS patients and ground patients in disability grade, Nottingham Health Profile (NHP) dimension score, or in mean number of problems with aspects of daily living.

Authors' Conclusions There was no evidence of reduced disability in HEMS survivors.

Commentary This paper, addressing morbidity outcomes in the same patient population addressed by the authors' earlier study on mortality (see above, Nicholl et al, BMJ. 1995), suffers from the same substantial flaws and a few extras. The authors administered a mail or personal interview survey consisting of two instruments, neither of which had been used or validated in trauma patients, and assessed such vagaries as "emotional reactions" and "social isolation" without presenting any case for the relevance of transport mode to these outcomes. Even if the surveys would have been validated in trauma, the low response rates (73% for HEMS and 63% for ground) undermine the ability to draw concrete conclusions from this paper.

• Celli P, Fruin A, Cervoni L. Severe head trauma. Review of the factors influencing the prognosis. Minerv Chir. 1997;52:1467-80.

Objective The study's objective was to review the impact of scene HEMS transport on mortality from severe head trauma.

Methods

Study Design Retrospective medical records study.

Setting The study HEMS program, Life Flight Helicopter Emergency Medical Service, was staffed by an RN/RN or RN/MD crew. Ground transported patients were attended by ALS or BLS personnel (frequency not given). All patients were cared for at the University of Nebraska at Creighton.

Time Frame Study patients were transported between January 1982 and December 1985.

Patients The study's primary focus was upon 44 scene-transported blunt trauma patients who had severe (GCS < 8) head injury, but not brain death, on hospital admission and who remained comatose during the first six hours of their trauma center stay. Twenty of the patients were HEMS transports and the other 24 were ground transports.

Analysis The study reported categorical analysis, though the authors did not provide much detail on statistical methods.

Results HEMS patients had significantly lower mortality than ground-transported patients (20% vs. 54%). HEMS patients were much more likely than ground-transported patients to undergo prehospital intubation (80% vs. 10%) and intravenous access placement (100% vs. 50%).

Authors' Conclusions The authors concluded that the improved prehospital stabilization associated with HEMS transport was responsible for outcome improvement in severely head-injured patients.

Commentary This study, reporting a series in which less than 10% of ground-transported patients with severe head injuries were intubated, is possibly best viewed as more of an argument for advanced life support (ALS)-level care than as a proof that HEMS improves survival. Nevertheless, the study provides support for a contention that HEMS may be important in maximizing survival in severe head trauma patients who do not have access to ground ALS.

• Cunningham P, Rutledge R, Baker CC, Clancy TV. A comparison of the association of helicopter and ground ambulance transport with the outcome of injury in trauma patients transported from the scene. J Trauma. 1997;43:940-6.

Objective The study's objective was to review the blunt trauma mortality impact of scene HEMS transport.

Methods

Study Design Retrospective cohort study based on a statewide trauma registry.

Setting The study was conducted in a mostly rural state (North Carolina). Patients were transported to eight Level I and II trauma centers.

Time Frame Study patients were transported between 1987 and 1993.

Patients The study enrolled blunt trauma patients who were transported by HEMS (n = 1,346) or ground (n = 17,144) directly from scenes to a trauma center.

Analysis Patients were grouped by ISS and RTS for Cochran-Mantel-Haenszel analysis, and a mortality risk ratio (based on ICD-9 code, RTS, age, and gender) was calculated for use in multivariate logistic regression.

Results A trend towards increased survival was observed in HEMS patients, but statistical significance ($p < 0.05$) was achieved only for patients with TSs between 5 and 12 and ISSs between 21 and 30. The HEMS term was not significant in multivariate logistic regression, but pertinent data (e.g., odds ratio and confidence interval when transport mode was forced into the model) were not reported.

Authors' Conclusions HEMS scene transport did not result in uniformly improved outcome compared with ground transport. Only a very small subset of patients transported by helicopter appear to have any chance of improved survival based on transport mode.

Commentary This well-conducted study attempted to address the HEMS mortality issue with an intuitively appealing methodology. These authors appropriately concluded that most patients in their study were of relatively low acuity, thus there were small numbers of patients in the important acuity midrange in which HEMS' potential benefit would logically be highest. Notably, the data were parsed into so many cells (5 ISS categories and 4 RTS categories, for a total of 20 cells per transport mode) that power was substantially limited. In the midrange of injury acuity, for patients with TSs between 5 and 12 and ISSs between 2 and 40, HEMS was associated with survival improvements in all eight cells but significance was achieved in only two cells. The authors' use of Cochran-Mantel-Haenszel analysis for their sparse strata data was completely appropriate, but their nonreporting of confidence intervals or power was unfortunate. The authors' overall conclusion, that only a subset of patients appear to benefit from HEMS transport, is in line with common sense, and their recommendations to attempt to identify that subset are well considered.

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• Younge PA, Coats TJ, Gurney D, Kirk CJC. Interpretation of the Ws statistic: application to an integrated trauma system. J Trauma. 1997;43:511-515.

Objective The study's objective was to review the blunt trauma mortality impact of scene HEMS transport to a London hospital with a waiting trauma team and comprehensive on-site surgical services.

Methods

Study Design Retrospective TRISS-based study

Setting The study was conducted in the London area, with all patients transported to the Royal London Hospital, a facility with a trauma commitment similar to that of Level I U.S. centers.

Time Frame Study patients were transported between August 1990 and August 1994.

Patients Study patients were 632 consecutive scene blunt trauma patients transported by the London HEMS system. There was no ground "control" group; survival was compared with patients in the U.K. Multiple Trauma Outcome Study (MTOS).

Analysis The study's analysis was similar to TRISS. The paper described the use of a standardized Ws statistic, which is intended for use when the M statistic denotes that the study patient population is too dissimilar to that of the MTOS group for use of the unadjusted W statistic. The Ws represents an estimate of the number of excess survivors per 100 patients attending a particular center that would be achieved if that center received patients with the same injury severity distribution as the reference database.

Results Overall, the HEMS system resulted in a standardized W statistic of 4.16 ± 2.21, meaning that the system was associated with 4 excess survivors per 100 transports, assuming a MTOS-like injury acuity distribution at the receiving hospital. The survival benefit appeared to be strongest in patients with injuries of lower (25–50%) probability of survival.

Authors' Conclusions The use of standardized Ws statistics can allow for trauma system evaluation, and the trauma system under study was associated with approximately 4 excess survivors per 100 patients (of MTOS-standardized acuity).

Commentary Despite its superior methodologic rigor, this study is infrequently mentioned in HEMS literature discussions. Some of this relative neglect may be related to the paper's esoteric title and subject matter, but though the paper provides strong evidence for mortality improvement, there is a more important obstacle to "pro-HEMS" interpretation of the study's results. While the authors analyzed a HEMS cohort, and consistently refer to the study trauma system as the "HEMS system," the study center provided a higher level of care than that available at U.K. MTOS hospitals. Thus, survival benefit could conceivably have been due to HEMS transport, receiving facility characteristics, or some combination of the two.

• Cocanour CS, Fischer RP, Ursic CM. Are scene flights for penetrating trauma justified? J Trauma. 1997;43:83-6.

Objective The study's objective was to evaluate medical efficacy of HEMS scene flights for noncranial penetrating trauma.

Methods

Study Design Retrospective study of prehospital and hospital records.

Setting Study HEMS patients were transported by Hermann Hospital's flight program, LifeFlight, to that Houston level I trauma center. LifeFlight was staffed with an RN/EMT-P crew with extended scope of practice (cricothyrotomy and needle thoracostomy), which exceeded that of Houston ground EMT-Ps.

Time Frame Patients were transported over a 12-month period between 1992 and 1993.

Patients Patients were 122 consecutive scene transports for noncranial penetrating trauma. Gunshot wounds accounted for 67%, stab wounds 29%, and shotgun wounds 4%. Most patients (75%) had ALS initial responders. For transport time analysis, there was no ground control group; times for ground transport were estimated based on distance.

Analysis The study's analysis was descriptive.

Results HEMS crews provided only three interventions (1 cricothyrotomy and 2 needle thoracenteses) beyond those of first-responding units when those units were ALS level, and two advanced interventions (intubations) in patients for whom BLS was the initial first response level. Overall, HEMS units intubated 13 patients (including two initially reintubated by ground ALS) in the ALS first-responder group. Calculations revealed no time savings associated with use of HEMS transport mode.

Authors' Conclusions Metropolitan-area scene flights for penetrating trauma were not efficacious as assessed by prehospital time or by HEMS crew provision of interventions. Such flights should be restricted to critically injured patients likely to require prehospital care by the HEMS crew that is beyond the capabilities of the ground responders, or when the scene flight is likely to significantly hasten the arrival of the injured patient to an appropriate trauma center.

Commentary With respect to the two ALS first-response patients reintubated by HEMS, there are no details given (e.g., reason for reintubation). There were also no data on the 11 patients whose intratransport "deterioration" prompted intubation. The editorial discussion following the paper highlights the high incidence of HEMS airway management and emphasizes that while they may not have provided interventions beyond the level of ground EMS, HEMS crews may have done a better job in at least one critical intervention—intubation—within ground providers' practice scope. Also mentioned in the paper's editorial discussion was the questionability of the paper's artificial calculation of ground transport times and the possibility that HEMS had been called in cases where prolonged ground transport was expected. Overall, the high incidence of HEMS-provided airway management and the flawed method of assessing ground prehospital times translate into a failure of this paper to provide persuasive evidence for the authors' conclusions. Indeed, some of the discussants' arguments that the results favor HEMS are as compelling as the authors' own interpretation of their data.

• Bartolacci RA, Munford BJ, Lee A, McDougall PA. Air medical scene response to blunt trauma: effect on early survival. Med J Aust. 1998;169:612-6.

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Objective The study's objective was to compare blunt trauma outcome for scene patients transported by a physician-staffed HEMS service with outcome as predicted by TRISS.
Methods
Study Design Retrospective TRISS-based study.
Setting The study HEMS program, NRMA CareFlight, was staffed by an MD/EMT-P crew. Patients were transported to the Westmead Hospital trauma center in Sydney, Australia.
Time Frame Study patients were transported between July 1986 and June 1994.
Patients The HEMS patients were 77 blunt trauma victims with ISS > 14. For ISS-matching analysis, each HEMS patient was matched with four randomly selected ground transported patients with ISS within 5 points of the HEMS patient, and treated in the same year.
Analysis Statistical analysis assessed both on-scene procedures and mortality, which was analyzed by two methods. The primary survival analysis was assessment of HEMS patient mortality as compared with TRISS-predicted mortality; lack of data availability precluded performance of TRISS analysis on ground-transported patients. In an additional assessment of HEMS survival benefit, HEMS patient mortality was compared with that of the ISS-matched ground transported patients.
Results The ISS-matched HEMS and ground patients had statistically similar mortalities [odds ratio and 95% CI for ground as compared with HEMS transport, 1.43 (0.74–2.78)], but ground-transported patients required significantly more interventions (e.g., intubations, IV line placements) in the emergency department (ED). TRISS analysis identified significant survival advantage associated with HEMS transport. There was a 50% reduction in expected mortality ($p < 0.001$), and the adjusted W statistic of 12.2 (95% CI, 5.3–19.1) was consistent with HEMS transport saving 12 lives per 100 patients.
Authors' Conclusions Scene HEMS response is associated with better prehospital care and reduced blunt trauma mortality.
Commentary Besides adding to the TRISS-based case for HEMS mortality improvement, this paper complements its case for HEMS benefit with data demonstrating potential reasons for greater survival.

• Brathwaite CE, Rosko M, McDowell R, Gallagher J, Proenca J, Spott MA. A critical analysis of on-scene helicopter transport on survival in a statewide trauma system. J Trauma. 1998;45:140-6.
Objective The study's objective was to review the mortality impact of HEMS vs. ground ALS scene transport for blunt trauma.
Methods
Study Design Retrospective cohort study.
Setting Patients were transported to 28 Level I and II centers throughout Pennsylvania, presumably by all HEMS and ground ALS agencies operating in the state (no information was given).
Time Frame Study patients were transported between 1987 and 1995.
Patients Eligible patients were those transported from trauma scenes by helicopter (15,938) or ALS-level ground units (6,473).
Analysis The primary analysis was performed with multivariate logistic regression. The authors' analysis controlled for age, sex, rural/urban status, hypotension, RTS, and ISS, which was analyzed as a categorical variable in five levels (1–15, 16–30, 31–45, 46–60, and 61–75).
Results Multivariate logistic regression revealed statistically significant effect modification, meaning HEMS effects on survival varied at different ISS levels. There was no mortality benefit for ISS groups 1 (ISS 1–15) or 5 (ISS 61–75). For the middle three ISS groups, however, HEMS patients were 2.1 ($p < 0.01$), 2.4 ($p < 0.01$), and 2.6 ($p < 0.05$) times more likely to survive, respectively.
Authors' Conclusions HEMS transport appeared to be associated with mortality improvement only for patients with ISSs between 16 and 60; use of HEMS in other patients may represent overtriage. Reappraisal of the cost–effectiveness of helicopter triage and transport criteria, when access to ground ALS squads is available, may be warranted.
Commentary In a compelling non-TRISS paper, the authors performed well-designed multivariate analysis on a large dataset adjusting for many important covariates. The conclusions—that HEMS is of benefit in moderately injured patients but not those at ISS extremes—are well supported by the authors' data and are equally consistent with common sense. Neither HEMS nor any other intervention will save lives of those who have non-threatening, or clearly lethal, injuries.

• Jacobs LM, Gabram SG, Sztajnkrycer MD, Robinson KJ, Libby MC. Helicopter air medical transport: ten-year outcomes for trauma patients in a New England program. Conn Med. 1999;63:677-82.
Objective The study's primary objective was to review the impact of a HEMS service on trauma mortality over a 10-year period.
Methods
Study Design Retrospective cohort study.
Setting The study HEMS program, Hartford LifeStar, was staffed by a crew consisting of a respiratory therapist and doubly credentialed RN/EMT-P. Transports were performed within a 150-mile radius of Hartford, Connecticut, with most patients taken to the Level I center Hartford Hospital.
Time Frame Study patients were transported between June 1985 and June 1995.
Patients Mortality assessment focused on 3,620 scene-transported trauma patients. There was no ground EMS comparison group.
Analysis Actual vs. predicted survival was assessed by comparing trauma score-adjusted mortalities between study and MTOS patients.
Results There was an overall mortality reduction of 13% associated with HEMS transport. For patients with scene trauma scores (TSs) between 4 and 13, the HEMS-associated mortality reduction was 35%; there was no mortality improvement in patients with TS < 4 or TS > 13.
Authors' Conclusions Rapid utilization of HEMS can have a dramatic impact upon patient outcome, especially within a select group of scene transported trauma patients with trauma scores ranging from 4 to 13.
Commentary The authors provide a sound explanation

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for their (relatively infrequently used) TS-based stratification, and a plot depicting TS-based HEMS vs. predicted survival curves supports the contention of mortality benefit in patients with moderate injury severity.

• Garner A, Rashford S, Lee A, Bartolacci R. Addition of physicians to paramedic helicopter services decreases blunt trauma mortality. Aust N Z J Surg. 1999;69:697-701.
Objective The study's primary objective was to compare blunt trauma outcome for scene patients transported by a physician-staffed HEMS service with outcome in patients transported by a paramedic-staffed HEMS service.
Methods
Study Design Retrospective cohort study
Setting The study HEMS programs, Westpac Hunter and NRMA CareFlight, were staffed by EMT-P/EMT-P and MD/EMT-P crews, respectively. Patients were transported to one of three receiving trauma centers in the Sydney region of Australia.
Time Frame Study patients were transported between January 1996 and April 1998.
Patients Eligibility was determined by blunt trauma with ISS of at least 10. There were 67 patients transported by physician-crew HEMS and 140 patients transported by the non-physician crew HEMS. TRISS analysis was performed on an unspecified number of ground EMT-P-transported blunt trauma patients (with ISS at least 10) presenting to the three participating centers during the study period.
Analysis Since the M statistic indicated poor correlation between study and MTOS cohorts, an adjusted W statistic was used to assess for survival benefit.
Results There were no significant differences between the two HEMS groups in terms of age, mechanism of injury, transport distance, and response, scene, or transport times. As compared with patients transported by paramedic HEMS crews, patients transported by physician HEMS crews were significantly more likely to be intubated (51% vs. 10%) or undergo thoracic decompression (12% vs. 1%). An adjusted W statistic of 13.4 (95% CI 7.8–19.1) suggested that there would be between 8 and 19 extra survivors per 100 patients transported by the physician-crew HEMS as compared with the paramedic-crew HEMS. There was no statistical difference between actual and TRISS-predicted mortality in the paramedic-crew HEMS or in the ground-transported patients.
Authors' Conclusions Physician-crew HEMS units perform a greater number of procedures on blunt trauma patients, significantly lowering mortality as compared with nonphysician HEMS crews. Critical care physicians should be added to paramedic helicopter services for scene response to blunt trauma.
Commentary As the authors note, the "physician-specific" interventions (e.g., neuromuscular blockade, aggressive airway management, needle decompression) postulated to result in their study's mortality improvement are commonly performed by nonphysician HEMS crews in the United States. Unfortunately, due to the fact that HEMS vs. ground survival was not a focus of the study, there was limited information on the ground "control" group. However, the fact that ground-transported patients as well as paramedic-crew HEMS transports (providing less advanced care than is the norm in the United States) had mortality similar to TRISS-predicted supports contention for a mortality benefit with advanced-level HEMS care.

• Phillips RT, Conaway C, Mullarkey D, Owen JL. One year's trauma mortality experience at Brooke Army Medical Center: is aeromedical transportation of trauma patients necessary? Milit Med. 1999;164:361-5.
Objective The study's objective was to assess whether HEMS transportation of trauma patients contributed to a trauma center's maintaining national mortality standards.
Methods
Study Design Retrospective cohort study.
Setting The study HEMS program, San Antonio AirLife, was staffed by an RN/EMT-P crew. Ground patients were transported by a EMT-P team. All patients were transported to the Level I Brooke Army Medical Center.
Time Frame Study patients were transported between October 1995 and October 1996.
Patients There were 687 ground (28.7% penetrating) and 105 HEMS (15.3% penetrating) adult and pediatric trauma patients.
Analysis Actual vs. predicted HEMS and ground patient survival was assessed using TRISS methodology.
Results The Z test demonstrated no statistically significant difference between actual and predicted trauma mortality rates for either HEMS or ground transported patients. HEMS patients were of significantly higher acuity, and had an average prehospital time 20 minutes longer than that of ground patients.
Authors' Conclusions HEMS evacuation of the more severely injured patients farthest from the trauma center resulted in mortality rates that met national standards. Since HEMS patients were of higher acuity and had longer prehospital times, HEMS triage was appropriate and HEMS played a role in the center's meeting national mortality standards.
Commentary Support for the authors' conclusion that their data demonstrate HEMS-associated mortality improvement requires something of a leap of faith. First, and most importantly, mortality was not better than that predicted by TRISS. Second, though HEMS patients were of higher acuity as noted by the study's authors, properly executed TRISS methods should have adjusted for this. Third, shorter ground ambulance prehospital times have not precluded other TRISS investigators (e.g., see above, Baxt et al., JAMA. 1983) from demonstrating increased survival in HEMS patients.

INTERFACILITY

• Moylan JA, Fitzpatrick KT, Beyer AJ, Georgiade GS. Factors improving survival in multisystem trauma patients. Ann Surg. 1988;207:679-85.
Objective The study's objective was to determine whether HEMS interfacility trauma transport was associated with mortality improvement compared with ground transport, and to attempt to elucidate possible explanations for outcome differences.

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Methods
Study Design Retrospective cohort study.
Setting The study HEMS program was staffed by a nonphysician crew and transported patients to Duke University Medical Center in North Carolina.
Time Frame Study patients were transported between 1985 and a nondisclosed time (in 1986 or 1987).
Patients All patients with TSs 12 or less, excluding local motor vehicle crash (MVC) victims, transported by ground (n = 194) or HEMS (n = 136) to Duke during the study period.
Analysis Survival rates of HEMS vs. ground patients in TS-stratified groups were compared after the authors ensured HEMS and ground patient similarity with respect to age, mechanism of injury, and organ systems injured.
Results In patients with TS between 12 and 10, HEMS (97.4%) and ground (97.9%) were similar. In patients with TS 9–7, HEMS and ground survival were 81.3% and 62.5%, respectively. For the TS 6–4 group, HEMS survival remained improved over ground (63% vs. 40%). For patients with TS 3–0, survival rates were similar in HEMS (15%) and ground (12%) patients. The authors report that for patients with TS between 5 and 10, in the midrange of injury severity, overall HEMS survival of 82.8% was significantly ($p < 0.001$) higher than that of ground patients (53.5%). The authors present data outlining the improved care provided by HEMS as compared with ground units with respect to airway and circulatory management.
Authors' Conclusions HEMS transport was associated with mortality improvement in interfacility transport trauma patients with trauma scores between 10 and 5. Transport interventions provided by HEMS crews were responsible for higher survival.
Commentary This study has two important strengths: a straightforward, if imperfect, means of injury stratification and an attempt at explaining improved survival found in HEMS patients. Importantly, the authors point out that there was no time savings associated with HEMS interfacility transport in their series. The relevance of the results to rural settings is appropriately emphasized by the authors.

• Boyd CR, Corse KM, Campbell RC. Emergency interhospital transport of the major trauma patient: air versus ground. J Trauma. 1989;29:789-94.
Objective The study's objective was to determine whether HEMS interfacility trauma transport was associated with mortality improvement as compared with ground transport.
Methods
Study Design Prospective TRISS-based study.
Setting The study HEMS program was staffed by an RN/EMT-P crew and transported patients to Memorial Medical Center in Savannah, Georgia. HEMS-transported patients were referred from EDs at 31 different rural hospitals with a one-way transport distance of at least 25 miles.
Time Frame Study patients were transported between July 1985 and July 1987.
Patients Study patients were consecutive adult interfacility HEMS (n = 103) and ground (n = 110) ALS-level transports of patients who had ISS > 15 or who required urgent operative intervention at the receiving center within two hours of arrival.
Analysis Actual vs. predicted survival was assessed by use of TRISS analysis.
Results By TRISS Z statistic, HEMS transport was associated with a significant mortality reduction of 25.4%. This benefit was accrued in patients with probability of survival of less than 90%. Ground-transported patient mortality was statistically similar to that predicted by TRISS. Prehospital times were significantly shorter in the HEMS group. There were indications of improved care (e.g., higher intubation rates) in the HEMS group as compared with ground paramedic-transported patients.
Authors' Conclusions HEMS transport was associated with mortality improvement in interfacility transport of blunt trauma patients with survival probability of less than 90% as predicted by TRISS.
Commentary This TRISS study was led by one of those who understands TRISS best. Its main strengths include its focus on interfacility mission type and its utilization of a ground EMS control group. The study's results, very compelling when the paper was published, may be less relevant today due to improvements in rural ED.staffing: only eight of the 31 referring hospitals had 24-hour physician coverage during their study.

SCENE AND INTERFACILITY

• Urdaneta LF, Miller BK, Ringenberg BJ, Cram AE, Scott DH. Role of an emergency helicopter transport service in rural trauma. Arch Surg. 1987;122:992-6.
Objective The study's primary objective was to evaluate whether HEMS transport was essential, helpful, or not a factor in preservation of life or limb in trauma patients.
Methods
Study Design Retrospective panel-based assessment of HEMS utility.
Setting The study was conducted at the University of Iowa College of Medicine, which received HEMS patients from a 120-mile radius of Iowa City. The university's HEMS program, Air-Care, was staffed by a single RN with MD accompanying "in some circumstances."
Time Frame Study patients were transported between April 1979 and March 1985.
Patients The study group was comprised of 916 consecutive trauma patients transported by HEMS to the study center from referring hospitals (79.5%) or scenes.
Analysis The primary analysis was descriptive, with a panel of reviewers categorizing HEMS transport as being essential, helpful, or not a factor.
Results The helicopter was judged to be essential in 14% and helpful in 12.9% of surviving patients; HEMS was judged to be beneficial in an additional 16.5% of patients who died from their injuries. Thus HEMS was beneficial in 43.4% and "not a factor" in 56.6% of transports.
Authors' Conclusions HEMS use results in rapid delivery of a high level of care that benefits many patients and maximizes the potential for survival. Even in patients judged to "not benefit" from HEMS transport by the current study's criteria, use of HEMS provides "excellent

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assistance" to rural physicians wishing to transport potentially seriously injured patients to a trauma center.
Commentary This study was an important addition to the literature in 1987, with the authors taking many steps to reduce the subjectivity inherent in their panel-review methodology. Despite the incorporation of objective review criteria, however, the finding that nearly half the patients (including many who died) benefited from HEMS transport is open to criticism as being potentially biased. In the current health care environment, it is probably not enough for HEMS programs to demonstrate "better" intratransport care; some morbidity or mortality outcome assessment is necessary.

• Schwartz RJ, Jacobs LM, Yaezel D. Impact of pre-trauma center care on length of stay and hospital charges. J Trauma 1989; 29: 1611-1615.
Objective The study's primary objective was to test a hypothesis that transport of patients directly from trauma scenes (by either air or ground) resulted in improved overall health care resource utilization as compared with initial transport to community hospitals with subsequent trauma center transfer.
Methods
Study Design Retrospective TRISS-based study incorporating stratified analysis to account for potential confounders of outcomes assessment.
Setting The study was conducted at the Hartford Hospital in Connecticut. The center's HEMS program, LifeStar, was staffed by a crew consisting of an RN and a doubly credentialed EMT-P/RN.
Time Frame Study patients were transported between April 1987 and February 1988.
Patients The study group was comprised of 877 consecutive trauma patients transported by HEMS (n = 168) or ground (n = 709) to the study center from referring hospitals (23.3%) or scenes (76.7%).
Analysis HEMS and ground study patients were categorized as scene or interfacility to create four subgroups. These subgroups then underwent stratified analysis and comparison of actual vs. predicted outcomes. The actual HEMS vs. ground survival analyses are alluded to in the paper but are not reported in detail.
Results The results relevant to survival are given in a table demarcated by deciles (e.g., 80–90%, 90–100%) of survival probability. In eight of ten rows of this table HEMS survival was higher than ground survival, though formal statistical comparison was not reported.
Authors' Conclusions Health care resource utilization was optimized when trauma patients were transported directly from scenes to the receiving trauma center by either air or ground. HEMS transport from either scene or interfacility missions was associated with better survival than expected, and better survival than that of ground-transported patients.
Commentary The authors state directly that HEMS patient survival was higher than expected and better than that of ground patients, so the paper was included in this review. However, since the paper's primary goal was not mortality analysis, these HEMS vs. ground comparisons are difficult to tease out of the other details in the paper.

• Moront M, Gotschall CS, Eichelberger MR. Helicopter transport of injured children: system effectiveness and triage criteria. J Pediatr Surg. 1996;31:1183-8.
Objective The study's primary objective was to evaluate whether air transport was associated with survival improvement in scene and interfacility pediatric blunt or penetrating trauma.
Methods
Study Design Retrospective TRISS-based study.
Setting The study was conducted at Children's National Medical Center in Washington, DC, which received patients from three different HEMS programs (Maryland State Police, MedSTAR, and the National Park Service) and multiple ground ALS and BLS services.
Time Frame Study patients were transported during an unspecified four-year period.
Patients The study group was comprised of consecutive patients <15 years old, with blunt or penetrating trauma, transported from scenes (approximately 76% in both air and ground patients) or hospitals to the receiving center. There were 1,460 HEMS-transported patients (63.3% of whom were involved in MVCs) and 2,896 (50.7% MVCs) ground transports; penetrating trauma accounted for less than 10% of the total patient population.
Analysis Statistical assessment of overall outcome was performed using TRISS analysis.
Results Per TRISS Z analysis, injury acuity-adjusted survival was significantly higher in the air-transport group as compared with the ground-transport group. W statistic calculation revealed that 11 lives were saved for each 1,000 HEMS transports.
Authors' Conclusions HEMS is associated with mortality improvement in pediatric trauma.
Commentary The study did not rigorously adjust for all potentially important factors (e.g., ALS vs. BLS care, scene vs. interfacility mission type) but given the direct comparison between air and ground transport and the large study numbers, the data substantiate the authors' conclusions. The paper and the editorials following also provide excellent discussion of the important issue of HEMS overtriage. The authors' suggestion of combining GCS and heart rate is not likely to be a simple answer to the overtriage problem, but their call for further refinement of triage criteria is certainly consistent with common sense.

References

1. Thomas SH, Cheema F, Cumming M, Wedel SK, Thomson D. Nontrauma helicopter emergency medical services transport: annotated review of selected outcomes-related literature. Prehosp Emerg Care. 2002;6:242-55.
2. Boyd CR, Tolson MA, Copes W. Evaluating trauma care: the TRISS method. J Trauma. 1987;27:370-8.

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