Helicopter EMS transport outcomes literature: Annotated review of articles published 2007-2009

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Abstract

Helicopter EMS (HEMS) and its possible association with outcomes improvement continues to be a subject of discussion. As is the case with other scientific discourse, 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 two subsequent reviews covering the literature through 2006. This review continues the series, outlining outcomes-associated HEMS literature for the three-year period 2007 through 2009.

Introduction

Despite the frequency of HEMS transport, there remains controversy surrounding its use and benefits. 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 twice, to cover studies published through 2006.[3-4] The current paper aims to extend the previous reviews, assessing outcomes studies published 2007-09. As with earlier reviews in the series, the article summaries include commentary intended to place the research into perspective. The primary goal of this article, like the prior reviews, is to present the most important HEMS outcomes literature published in the 2007-09 time frame as an aid to those who wish to explore the evidence basis for HEMS use.

Methods

A computerized literature search was performed. The search database was the National Library of Medicine's MEDLINE (online Index Medicus), extending from 2007 through 2009. The search methods and terminology used for this review were the same as those employed, and reported, in the previous reviews.[1-4] For the current review, there were over 1000 studies assessed for possible inclusion (by review of title, abstract, or full-length paper).

As noted for the previous reviews, eligibility for article inclusion was usually easy to determine, but there was inevitably some degree of subjectivity. The authors acknowledge that the process of article selection may have excluded some worthy research, and emphasize that the attempt to capture all relevant papers probably missed some studies.

The papers that are included in this review are categorized into diagnostic areas. The first category, *Trauma – Scene Transports*, assesses studies of HEMS use in transporting injured patients from the scene. For interpretation of the trauma studies, some knowledge of

TRISS methodology (survival probability based upon trauma and injury severity scores as well as age and injury mechanism) is helpful. TRISS is outlined in detailed elsewhere.[5] The next category, *Trauma – Scene & Interfacility*, addresses the use of HEMS for a patient population comprising both primary (*i.e.* scene) and secondary (*i.e.* interfacility) HEMS missions. The review concludes with *Drowning* and *Cardiac* sections. Within categories, articles are listed chronologically with earlier papers first.

TRAUMA – SCENE TRANSPORTS

- McCowan CL, Swanson ER, Thomas F, Handrahan DL. Outcomes of blunt trauma victims transported by HEMS from rural and urban scenes *Prehosp Emerg Care* 2007; 11: 383-388.

Objective The study's goal was to determine whether HEMS-transported rural scene trauma patients have the same mortality as HEMS-transported urban scene trauma patients.

Methods

Study design This was a retrospective consecutive-case review of records from two HEMS services and three receiving Level I trauma centers. The authors' endpoint analysis incorporated multivariate logistic regression controlling for age, gender, and ISS.

Setting The trauma centers in the study are located in Salt Lake City, Utah; the regional population is 1.4 million. The area's two HEMS services are staffed by paramedic/nurse and nurse/nurse teams (variable depending on patient age).

Time frame Study patients were those transported during 2001.

Patients The study included 271 urban and 141 rural blunt trauma scene transports. Study patients were aged at least 15 years, and all blunt trauma scene transports were included except for those related to winter resort activities. The authors defined "rural" counties *a priori*, as those with fewer than 99 residents per square mile.

Results There were no significant differences between rural and urban patients' age, gender, or receiving hospital, but the urban group had significantly more auto-pedestrian/bike victims and the rural group had more "other motorized" vehicle crash victims (*e.g.* ATV, snowmobile). Urban transports were characterized by shorter scene times (16 *vs.* 21 minutes), shorter flight times (30 *vs.* 79 minutes), and greater likelihood of pre-HEMS IV access and ETI. Urban and rural patients had similar vital signs upon HEMS arrival, but the former group had lower GCS and TS. The main endpoint analyses found that rural and urban patients outcomes were similar with respect to hospital and ICU length of stay, ED death, or inpatient mortality; there were also no differences in discharge status dispositions.

Authors' conclusions After controlling for age, gender, and ISS, there were no significant mortality differences between rural and urban scene trauma patients undergoing HEMS transport. The lack of mortality difference was also present when analysis was limited to motor vehicle and motorcycle crashes.

Commentary As the stack of TRISS-based studies demonstrating HEMS' trauma outcomes improvement grows, there is shrinking incremental benefit of adding another such study onto

the pile. Thus, novel approaches to assessing for HEMS benefit are particularly valuable. These authors took a unique and clever approach to the outcomes assessment problem, taking as their foundation the well-known fact that trauma in the rural setting is associated with worse outcome. There is always potential for residual confounding (*e.g.* by acuity), but the Utah group went to great lengths to minimize study flaws. The authors' discussion incorporates many points of interest and relevance, but the bottom line is that HEMS use appears to be an "equalizer" for rural trauma patients – air transport eliminated the rural/urban trauma outcomes differences for both mortality and nonmortality endpoints.

- Davis DP, Peay J, Good B, et al. Air medical response to traumatic brain injury: A computer learning algorithm analysis. *J Trauma* 2008; 64: 889-897.

Objective The study's goal was to determine whether air medical transport of head-injured patients from trauma scenes was associated with mortality benefit.

Methods

Study design This retrospective study generated predictive models using artificial neural network (ANN), support vector machine (SVM), and decision tree methods. ANN was used to calculate differential survival (actual *vs.* predicted) for each patient, and SVM used chi-squared testing to compare (between air- and ground-transported patients) the ratios of unexpected survivors to unexpected deaths. Decision tree analysis was used to explore the indications for air transport.

Setting This was a registry-based analysis from the San Diego County Trauma Registry.

Time frame Study patients were those transported during 1990-2003.

Patients The study included 11,961 patients with head AIS at least 3; 3,023 were transported by air and the others by ground ambulance (usually with paramedic-level care).

Results All three algorithms generated by the study's methodology predicted a survival benefit associated with air transport across all patients. The benefit was most pronounced in cases with higher acuity as denoted by GCS, ISS, head AIS, or hypotension.

Authors' conclusions HEMS confers a survival advantage in traumatic brain injury (TBI).

Commentary This was not a "TRISS" study, but some parts of the methodology are reminiscent of that approach. Specifically, the ability of the study to identify unexpected survivors (and unexpected deaths) is an important function. The authors' study, while necessarily complex, appears to represent an unbiased, reproducible, valid (as tested statistically) mechanism for identifying the differential effect of transport mode on survival outcome. Based upon means of the three best ANN models, the differential survival attributable to HEMS as compared to ground transport, was calculated to be 3.6 per 100 (95% CI 3.4 to 3.9) for all patients studied. When the study group was AIS at least 4, the survival benefit rose to 5.7/100; in patients with GCS between 3-8 the benefit was 7.1/100 patients. Since these same authors have also demonstrated that HEMS improves non-mortality outcome (*i.e.* functional survival), the results of the current study's methods are a useful complement to the existing body of evidence that strongly suggests HEMS impacts TBI outcome.

- Ringburg AN, Spanjersberg WR, Frankema SPG, et al. Helicopter Emergency Medical Services (HEMS): Impact on on-scene times. *J Trauma* 2007;63:258-262.

Objective The study's objective was to compare pre-hospital on-scene times (OSTs) for patients treated by nurse-staffed ground emergency medical services (EMS) with OSTs for patients treated by a combination of ground EMS and physician-staffed helicopter emergency medical services (HEMS). Due to relatively short ground transport times from scenes, the responding HEMS unit rarely performs actual patient transports; HEMS crews perform patient stabilization and attend the patients while *en route* to hospital. A second aim was to investigate the relationship between length of OST and mortality.

Methods

Study design The study was a trauma registry study using regression analysis to compare EMS to EMS/HEMS-treated patients.

Setting The study patients were those at trauma scenes in the area served by HEMS based out of Rotterdam, in The Netherlands. Patients were transferred to a high-level trauma center (Erasmus University Hospital).

Time frame Study patients were cared for between January 2002 and 2004.

Patients Study patients were all (n = 1,457) adult (>15 years old) trauma scene transports to Erasmus during the study period; 260 (18%) in the HEMS group and 1,197 (82%) in the EMS group.

Analysis Mean pre-hospital on scene times between groups were compared using Student's t tests. A custom-fitted regression model was defined to compensate for potential selection bias. All commonly used predictive variables were evaluated for their contribution to the model. The variables Revised Trauma Score (RTS), age, Injury Severity Score (ISS), whether the trauma occurred inside or outside the uniform daylight period, and mechanism of injury were found to have significant predictive value and were fitted into the model. Logistic regression models were used to analyze the influence of OST on mortality.

Results The number of trauma patients included for analysis was 1,457. HEMS patients had longer mean OSTs (35.4 vs 24.6 minutes; p <0.001). After correction for patient and trauma characteristics (including RTS, age, ISS, daytime/nighttime, mechanism of injury), the difference in OSTs between the groups was 9 minutes (p <0.001). Unadjusted logistic regression suggested a 20% higher chance of dying associated with increased OST by 10 minutes (OR, 1.2; p = .001). However, adjusted analysis found that for HEMS-attended patients the effect of OST on mortality was eliminated (OR 1.0, p = .89).

Authors' conclusions Combined EMS/HEMS assistance at an injury scene is associated with longer OST, but this prolongation of OST did not have the anticipated (undesirable) effect on mortality. HEMS response to a trauma scene is associated with earlier provision of critical care interventions that, while increasing prehospital time, provide more rapid "golden hour" procedures that improve mortality and eliminate adverse effect from prolonged OSTs.

Commentary This paper, from well-published and methodologically accomplished

investigators in The Netherlands, addresses HEMS outcomes in an indirect manner. The arrangement of HEMS response and subsequent ground transport, unusual in the U.S., has been shown to work well in these authors' country.[6] Regardless of how patients get to the hospital, the important HEMS intervention is – in the judgment of the study authors – getting the experienced crews to the patients. The fact that the provision of advanced care in the prehospital setting negated the adverse outcomes expected due to prolonged on-scene time could be interpreted two ways. It could be said that the savings of the time associated with more prehospital procedures would get the patients to the trauma center faster, and their "golden hour" interventions could be instituted earlier. This argument may hold true for patients whose ground transport times would be anticipated to be shorter than the 9-minute time prolongation associated with HEMS crew interventions. For other patients, however, the authors' results do seem to make the case that a little prolongation of on-scene time in their setting allows for earlier institution of life-saving interventions.

- Cudnik MT, Newgard CD, Wand H, Bangs C, Herrington R. Distance impacts mortality in trauma patients with an intubation attempt. *Prehosp Emerg Care* 2008; 12:459-466.

Objective Out-of-hospital endotracheal intubation (ETI) has been associated with adverse outcomes; whether transport distance changes this relationship is unclear. The authors sought to determine whether there was an association between transport distance and prehospital ETI's impact on outcome.

Methods

Study design The study was a retrospective analysis of a consecutive-case adult cohort.

Setting The study covered 19 counties in Oregon's northwestern portion (including the greater Portland metropolitan region).

Time frame Study patients were accrued to cover 2000-2003.

Patients Study patients were consecutive (n = 8,786) adult (>14 years old) trauma scene transports to the study center over the study years. Of these patients, 534 (6%) underwent prehospital ETI, 307 (57.5%) with rapid-sequence induction (RSI) and 227 (42.5%) without RSI.

Analysis Multivariate logistic regression analysis was used to evaluate the association between prehospital ETI and mortality, and also to assess for effect modification (*i.e.* statistical significance of an interaction term) between transport distance and ETI. The authors used propensity scoring (for ETI likelihood) and adjusted for potential patient and injury-type confounders, creating estimates for ETI-associated mortality odds ratios (ORs).

Results Of 8,786 patients analyzed, 534 (6%) underwent prehospital ETI. Helicopter transport was used for 962 (10.9% of 8786) patients; 211 of 962 (21.9%) were intubated by HEMS crews. Patients requiring ETI tended to have lower GCS scores, higher injury acuity, and worse outcomes than nonintubated patients. After adjusting for potential confounders and the propensity to be intubated, the authors found prehospital ETI to be associated with an

increased mortality (OR 2.1, 95% CI 1.3-3.2) and increased risk of complications (OR 2.1, 95% CI 1.5-2.9). The authors found an association between transport distance and ETI-associated mortality: shorter transport-distance patients had the highest ETI-associated odds of death (OR 4.0, 95% CI 2.1-7.6) and risk of complications (OR 4.1 CI 2.4-7.1). More importantly for this review, the authors found a strong across-the-board (*i.e.* ETI and non-ETI patients) association between HEMS (*vs.* ground) transport and improved survival (OR 0.3, 95% CI 0.2-0.5).

Authors' conclusions Prehospital ETI is associated with an increase in mortality among trauma patients at all distances from Level 1 trauma centers, with the greatest prehospital ETI-associated mortality risk increase occurring for patients who are relatively close to the trauma center. Helicopter transport is associated with improved survival in trauma patients, even after adjustment for ETI status and transport distance.

Commentary As noted in previous reviews of the HEMS literature, studies like this one – those that were never intended to assess HEMS' impact on survival – are a double-edged sword. It is vital to avoid overinterpretation of a "secondary' result that was outside the *a priori* intent of the study design. However, the consistently strong association (in these authors' regression models) between survival improvement and HEMS transport should not be ignored. The finding may have been "incidental," but the HEMS term's statistical and clinical significance in such a methodologically sound study is noteworthy – and perhaps even more given the low likelihood of author bias toward either side of the HEMS debate.

- Shepard M, Trethewy C, Kennedy J, Davis L. Helicopter use in rural trauma. *Emerg Med Australas* 2008; 20: 494-499.

Objective This study's main objectives were descriptive. The investigators also set out to assess whether there were any time savings or outcome advantages accrued by HEMS use or physician staffing, respectively.

Methods

Study design This study was a retrospective medical records review.

Setting The study patients were transported by the Hunter New England Rescue Helicopter Service, which serves the areas northwest of New South Wales in Australia. The HEMS staffing model usually comprises non-physician prehospital personnel, with the addition of physician crew based upon pretransport judgment that patients might need more advanced care. The physicians who participated in HEMS transports were specially trained doctors with prehospital experience. Patients were transported to Tamworth Rural Referral Hospital in New South Wales.

Time frame The study included all HEMS trauma missions from January 2004 through November 2006.

Patients Study patients included 129 HEMS scene transports, nearly all for blunt trauma. Of these patients 50 (29%) had an ISS >15 and the average ISS for the study cohort was 12.3.

Analysis The analyses included descriptive approaches as well as univariate assessments. In

order to determine whether physician staffing was appropriately triaged, ISS scores were compared between physician-staffed and nonphysician-staffed flights. There were insufficient deaths (2) for meaningful mortality analysis. For the endpoint of transport time, Global Positioning System (GPS) devices were used to estimate road travel times. Times were then compared using Student's *t* test, within three one-way transport distance categories (<50 km, 50-100 km, >100 km).

Results There was no significant difference between ISS for patients on physician-staffed versus nonphysician-staffed transports. Overall, the average time from dispatch to trauma scene arrival was 48.6 min and the average on-scene time was 50.3 min. The average distance from scene back to the receiving hospital was 160.4 nautical miles. When the times required for HEMS *vs.* (calculated) ground vehicle transport times were compared in the three *a priori*-defined distance groups, the only subcategory with a HEMS time advantage was for distance exceeding 100 km. For transport distances of 50-100 km, there was no time difference between HEMS and ground transport; ground transport was significantly faster when transport distances were less than 50 km.

Authors' conclusions The conclusions most relevant to this review were 1) addition of a physician to a HEMS crew has no mortality impact, and 2) HEMS response to a trauma scene within 100 km of the receiving hospital does not result in faster time-to-trauma center.

Commentary The ability to draw definitive conclusions from this dataset is limited by a number of factors. There is potential for selection bias. Furthermore, the very low mortality of the HEMS patients was correctly identified by the authors as problematic. First, there is the obvious fact that such a low death rate indicates room for improvement in triage. Second, the low mortality precludes meaningful assessment of associations between survival and time-distance or staffing variables. The pitfalls of using computers to retrospectively estimate ground transport times have been iterated in previous discussions.[3] Overall, the study should prompt further consideration as to whether HEMS is really necessary for responses within 100 km, in areas that are similar to the study region.

- Berlot G, La Fata C, Bacer B, et al. Influence of prehospital treatment on the outcome of patients with severe blunt traumatic brain injury: a single-centre study. *Eur J Emerg Med* 2009; 16: 312-317.

Objective This study's objective was to compare the outcomes of TBI patients who were transported by HEMS versus ground ambulance.

Methods

Study design This was a retrospective medical records review.

Setting This study took place in northeastern Italy in a region called Fruili-Venezia Giulia (FVG), with a population of about 1.5 million. Patients with TBI were delivered to one of two regional neurotrauma centers. HEMS operates during daylight hours, with a crew of two nurses and an anesthesiologist with prehospital experience. The comparator ground ambulance service, staffed by two nurses (with occasional addition of a non-specialized physician), covers

a much more limited geographic area around Trieste, the capital of FVG.

Time frame This study included patients transported from January 2002 to December 2007.

Patients Study patients were 194 cases of scene response to patients who were ultimately found to have ISS at least 15 and a head abbreviated ISS ($aISS_{head}$) of at least 9. The HEMS and ground ambulance groups consisted of 89 and 105 patients, respectively.

Analysis Initial univariate analyses were performed to assess for baseline differences between HEMS and ground patients. Subsequently, the primary study outcomes of mortality and discharge condition were assessed for HEMS versus ground. The discharge conditions were divided *a priori* into 3 groups: 1) alive with no deficit or minor neurological symptoms, 2) alive with severe neurological disabilities (*e.g.* persistent vegetative status, hemiplegia), and 3) deceased. Secondary outcomes included (among others) prehospital times, hypotension upon arrival at the receiving hospital ED, in-hospital times (including time from receiving hospital arrival to arrival at ICU or operating suite), and ICU and hospital lengths of stay. Statistical analyses included Student's *t* test and the Wilcoxon rank-sum test for continuous variables, with employment of chi-square analysis and Fisher's exact test for categorical variables.

Results Univariate analysis identified no statistical differences between HEMS and ground groups with respect to on-scene GCS, ISS, $aISS_{head}$, or age. The primary endpoints of mortality and neurological outcome both favored HEMS. Overall, air transported patients had significantly lower mortality than ground transported patients (21% versus 25%). HEMS patients also had better neurological outcome. Within the group of surviving patients, HEMS patients were significantly less likely than ground patients to have severe neurological deficit (25% versus 31%). Analysis of the secondary endpoints showed that HEMS patients had significantly longer pre-receiving center times (66 versus 38 minutes), but that receiving center stabilization time (*i.e.* time in ED pre-ICU or pre-operating room) was significantly shorter for HEMS patients (99 versus 115 minutes). HEMS patients were significantly more likely to undergo prehospital intubation (82% versus 38%), and had twice as many intravenous lines placed on a per-patient basis. In terms of minimizing potential for secondary brain injury, ED arrival blood pressure was significantly higher in the air transported cohort (mean 133 versus mean 110, $p < .001$). There were no differences between air and ground transported patients, with respect to number of neurological procedures, duration of intubation, or ICU or hospital lengths of stay.

Authors' conclusions The authors believe the better outcomes, in terms of both survival and neurological condition, that were seen in the HEMS group were due largely to enhanced skills and experience of the air medical teams. Longer pre-receiving center times for HEMS patients were offset by the increased number of interventions provided during the prehospital phase. In patients with severe TBI, the concept of the "golden hour" should be modified to adjust for interventions that occur during that critical time period.

Commentary

This study, like some others from the same region of Italy,[7-9] makes a strong case for HEMS' salutary outcome effect in an "apples-to-oranges" assessment (of greater capability HEMS

versus lesser capability ground EMS). The study has limitations – among them the lack of multivariate analysis and the non-adjustment for prehospital times in the reporting of some EMS interventions (*i.e.* reporting of total volume of fluid resuscitation, rather than volume per hour). In terms of secondary outcomes, the potential for secondary brain injury (which is indeed an important surrogate marker) may have been better evaluated by assessing incidence of hypotension rather than mean blood pressure. Overall, however, the reduction in mortality, and the favorable effects of HEMS upon neurological outcome, combine effectively with other data suggesting HEMS improves outcome in TBI patients.[10-11]

TRAUMA – SCENE & INTERFACILITY

- Mitchell AD, Tallon JM, Sealy B. Air versus ground transport of major trauma patients to a tertiary trauma centre: A province-wide comparison using TRISS analysis. *Can J Surg* 2007; 50: 129-133.

Objective The study's objective was to compare the outcomes of blunt trauma patients transported by HEMS, as compared to ground EMS, in a primarily rural, province-wide integrated trauma system with a single tertiary receiving center.

Methods

Study design The study was a retrospective trauma database review.

Setting The setting was the Queen Elizabeth Health Sciences Centre and Dalhousie University, Halifax, Nova Scotia. The HEMS unit is staffed by a nurse/paramedic team, and operates around the clock.

Time frame Study patients were those who arrived at the study hospital between 1998-2002.

Patients Study patients were all (n = 791) adult (>15 years old) blunt trauma scene transports to the study center during the study period, with ISS at least 12; 237 (30%) were transported by HEMS and 554 (70%) were transported by ground EMS. Median ISSs for air and ground patients were 25 and 20, respectively. Only 16% of HEMS transports came directly from the scene to the study center; 56% of ground EMS patients were scene transports.

Analysis The analysis used TRISS. Importantly, there was a ground control group, so the performance of HEMS and ground EMS could be compared against TRISS-predicted, as well as against each other. This is important, given the opposite directionality of air and ground EMS effects on outcome (see below).

Results As compared to TRISS-predicted survival, HEMS patients had significantly better outcome – a 25% improvement in mortality as compared to predicted. Ground EMS transported patients not only failed to have improved outcome over TRISS-predicted, but they actually had significantly *higher* mortality than predicted by TRISS; in this study ground transport equated with a 10% increase in mortality. With a *W* score of 6.4, HEMS was found to result in 64 lives saved per 1000 transports. The negative *W* score of -2.4 for ground EMS indicated that there were 24 unexpected *deaths* per 1000 ground ambulance transfers. In *post-hoc* analysis excluding falls, the deleterious effects of ground EMS transport disappeared: outcomes in the non-fall group for ground EMS were equal to TRISS-predicted. In the non-

fall group, however, HEMS patients still had a significantly improved outcome over TRISS-predicted (*W* of 6.6 indicating 66 lives saved per 1000 transports).

Authors' conclusions This first province-wide study, focusing on a rural area, finds that HEMS transport of patients with ISS at least 12, is associated with significantly improved outcomes as compared with ground transport.

Commentary As the authors themselves are quick to note, their methodology benefits from the availability of a single trauma database covering the entire province. All of the system's trauma patients are thus captured in the analysis, and the authors thus avoid the selection bias that cripples some HEMS studies.[12] In essence, the authors have conducted a population-based study, with minimization of confounding variables, in a setting ideal for detecting a HEMS benefit (a rural, maritime province with a single tertiary trauma center). If the benefit of HEMS is assessed as the difference in outcome as compared to ground transport, this study demonstrates that – in a setting admittedly ideal for HEMS benefit – air medical transport saves 88 lives per 1000 transports, and decreases mortality 35%. Importantly, the study's external generalizability is improved by the fact that both scene and interfacility transports were assessed.

- McVey J, Petrie D, Tallon J, Malay S, Colpitts K. Air vs. ground transport of the major trauma patient: A natural experiment. *Prehosp Emerg Care*; 2009 (e-published ahead of print).

Objective To compare the outcomes of adult trauma patients transported to a Level 1 trauma center by helicopter vs. ground ambulance, using a unique "natural experiment" design to obtain the ground comparison group while reducing potential confounders.

Methods

Study design The study was a retrospective analysis of data in two databases (the HEMS database and a province-wide trauma registry). The adult trauma patients were split into 3 groups: *Group 1* consisted of adult trauma patients transported to a tertiary care trauma center by air transport. *Group 2* patients were those triaged to HEMS (*i.e.* accepted by the online Medical Control Physician for air transport), but transported by ground due to aviation issues. *Group 3* included "all other" adult trauma patients transported by ground ambulance.

Setting The study was a retrospective study from the largely rural Province of Nova Scotia. There is a single helicopter which serves the entire province (population about one million), executing about 600 missions per year. All provincial patients go to a single trauma center. The HEMS unit is staffed by a nurse/paramedic team, and operates around the clock.

Time frame Study patients were those transferred between July 1, 1997 and June 30, 2003.

Patients The study included 397 adult (at least 16 years of age) trauma patients flown by LifeFlight (*Group 1*), 57 ground-transported patients initially triaged to HEMS (*Group 2*), and 1195 patients who were initially triaged to, and subsequently transported by, ground EMS (*Group 3*).

Analysis The primary outcome of interest of this study was mortality. The analyses that were

performed used TRISS-based methodology.

Results There was no statistically significant difference between *Group 1* and *Group 2* with respect to mean age, gender, percentage with blunt injury, AIS, and ISS; *Group 3* was of lesser acuity. There was no difference in the time between injury and trauma center arrival, between *Group 1* and *Group 2*. *Group 1* patients had a proportion of scene calls (20%) that was higher than that of *Group 2* (7%); *Group 3* patients were mostly (58%) scene transports which was related in part to their being more urban in nature. As compared to *Group 2* patients (whose mortality was equal to TRISS-predicted), *Group 1* status was associated with statistically significant survival improvement (5.61 more lives per 100 transports). *Group 3* patients had the worst outcome, with a survival *less* than that predicted by TRISS (W = -2.02).

Authors' conclusions This unique natural experiment led to methodological improvement in matching air versus ground cohorts, and reduced confounding. Using naturally assigned patient groups, air transport of the adult major trauma patient in Nova Scotia is associated with significantly improved survival as compared to ground transport of similar patients.

Commentary Although the study has some limitations (as reported by the authors), its message is potent given the methodological strengths of the approach and the fact that it extends (by both methodology and date) the study of Mitchell *et al* from the same area.[13] First, some of the study's shortcomings should be acknowledged. The study area is largely rural, with prolonged prehospital times and only a single tertiary trauma center. The results, however internally valid they may be, are thus of uncertain external validity when considering more urban areas. The authors also identify imperfections associated with TRISS use, although they correctly point out the lack of a preferable alternative. In any even, given the particular natural experiment design used in this study, any analytic technique would have to be truly biased (*e.g.* give an unfair advantage to HEMS as compared to ground EMS patients) in order to lead to spurious results. There is no reason to believe that TRISS would be biased in this population.

What does this study add to the (few dozen) TRISS studies that suggest some HEMS-associated outcomes improvement? While the authors' point estimate for lives saved per 100 transports is remarkably consistent with that of the preponderance of the literature, [2-4, 14] there are aspects to the current study that set it apart for methodological interest and excellence.

First, this is a province-wide study, population-based. In such a relatively small population (with only one major trauma center), this means that the selection bias that plagued some other HEMS natural experiment studies in trauma[12] and non-trauma[15] is substantially reduced. Second, the authors' concurrent natural experiment design is unique in the trauma literature, and superior (in its minimization of selection bias) to the only similar study – of cardiac patients – in the HEMS nontrauma literature.[15]

The use of concurrent design, in which the triage decision-making was the same for *Group 1* and *Group 2*, is powerful. The "before-and-after" approach characterizing the other HEMS natural experiment trauma studies is useful, but potentially limited by non-HEMS trauma system changes.[12, 16-17] The strength of the current study is enhanced by the facts that the system (and patients) were served by only one helicopter, with one dispatch center, and by one

tertiary trauma center.

The fact that the pre-trauma center times were similar in *Group 1* and *Group 2* may or may not mean that the HEMS logistics contributions were minimal in every case. However, the similarity in pre-trauma center times does indicate that the time variable was not likely an overriding factor in overall survival benefit.

DROWNING

- Barbieri S, Feltracco P, Delantone M, et al. Helicopter rescue and prehospital care for drowning children: two summer season case studies. *Minerva Anestesiol* 2008; 74: 703-707.

Objective This study examined the neurological outcomes of non-fatal pediatric immersion injuries, in patients with on-scene apnea, who were treated and transported by HEMS.

Methods

Study design This was a retrospective observational report based upon medical records review.

Setting This study took place in the Veneto Region on the coast of Italy. The area has a coastline of 150 km and a summer population of about 2.5 million. The HEMS unit is staffed by an anesthesiologist and a nurse with prehospital training. Patients were transported to a regional hospital with pediatric intensive care expertise.

Time frame Data were collected during the May-October time periods for two years (2006, 2007).

Patients Of the 14 pediatric submersion victims, 9 (64%) and were rescued from public pools and 5 (36%) were rescued from lakes or rivers. The victims were up to 16 years old with most of the victims being 4 years old or younger (71%). Ten (71%) were male. While most of the incidents were not witnessed, available data identified submersion times ranging from 5 to 15 minutes. All victims were first rescued by bystanders or a BLS paramedic service, and all were in respiratory arrest at the time of initial rescue.

Analysis Analysis was descriptive. Survival rates and neurological outcomes were assessed at time of discharge and at a 3-month follow-up.

Results At the time of HEMS assessment, 8 of 14 (57%) had deep cyanosis and 10 of 14 (71%) remained in cardiocirculatory arrest despite receiving basic life support efforts by bystanders and BLS-level ground ambulance crews. HEMS crews intubated all patients upon air medical team arrival. HEMS also performed ACLS maneuvers on all patients for a period of pretransport time ranging from 10 to 50 minutes; only 2 failed to respond with a perfusing rhythm within 30 minutes. All patients had a perfusing rhythm by the time of loading onto the helicopter. During flight, 5 patients had persistent hypotension requiring fluids and inotropic support. All victims were mildly hypothermic (mean rectal temperature <35 °C; range 32-36 °C). IV access was attained on all patients. The on-scene GCS was <8 in all cases. During the transport (average flight time, 14 minutes with a range of 8-20 minutes), the children were warmed with protective blankets. On arrival to the hospital, 10 children had a GCS between 10 and 13, and 2 remained <8. While all patients spent 3-6 days in the intensive care unit,

survival with complete/normal neurological recovery occurred in every case. Lack of neurological sequelae was confirmed at three-month follow-up in all cases.

Authors' conclusions The advanced interventions provided by HEMS crews (*e.g.* airway and hemodynamic support) were responsible for improved outcome. Promptly dispatching a helicopter with a specialized medical crew is worth the expense as it provides an increased chanced of survival.

Commentary In one sense, the series is certainly impressive. The results are attention-getting: 100% neurologically intact survival in a group of 14 patients with cardiorespiratory arrest from near-drowning. On the other hand, the observational nature of the study combines with the lack of a ground EMS control group to attenuate the strength of conclusions about HEMS' impact. It seems likely that, in an area where the choice is either BLS-level ground response or extended practice-scope HEMS response, pediatric immersion injury patients' best chance at optimal outcome may include air medical care.

CARDIAC

- Blankenship JC, Haldis TA, Wood GC, et al. Rapid triage and transport of patients with ST-elevation myocardial infarction for percutaneous coronary intervention (PCI) in a rural health system. *Am J Cardiol* 2007; 100: 944-948.

Objective This study examined the endpoints of time savings and health outcomes, to assess the effects of a new triage and HEMS transfer system designed to expedite community hospital evaluation and referral of STEMI patients to a PCI center.

Methods

Study design This study was "ambispective" in that some of the data were assessed retrospectively, and other patients' data were assessed prospectively. In mid-July 2004, retrospective chart review was performed to assess study variables back to January 2004. From mid-2004 through the end of the study period (December 2005), data were entered prospectively. The overall study design was a "before-and-after" approach, in which endpoints of interest were compared prior to, and after, January 2005 institution of new protocols for community hospital STEMI care and expedited HEMS dispatch. In brief, the protocol changes which were effective mid-way through the study included: 1) community hospital STEMI care changes emphasizing time savings (*e.g.* elimination of heparin and nitroglycerin infusions), 2) simultaneous PCI lab and HEMS activation from a single call to the receiving center, and 3) bypass of the receiving center's ED after HEMS transport.

Setting This study took place in central Pennsylvania, with the receiving center (Geisinger Medical Center) serving 37 counties with a population of 2.4 million. Geisinger is a 437-bed rural PCI center, and operates 4 helicopters based at 4 sites in central Pennsylvania. HEMS staffing is primarily by a nurse and flight paramedic, with occasional physician crewmembers. The study HEMS service had a high completion rate (97%) for the cardiac patients transported during the study period.

Time frame This study took place from January 1, 2004 to December 31, 2005.

Patients Patients eligible for inclusion were drawn from STEMI transports to the study center over the study period. Exclusion criteria included transport >12 hours after symptom onset, failure of thrombolytic therapy, or PCI contraindications. Most of the 226 patients comprising the study sample were male (80%), and the mean age was 58.

Analysis The main time endpoint was the proportion of patients with a time interval from initial community hospital presentation to wire-crossing (in the PCI lab) of under 90 minutes. The time periods were reported as medians, and intervals for the two study periods were compared using nonparametric Kruskal-Wallis testing. Other continuous variables were assessed using Students *t* test. Categorical data were compared using chi-square or Fisher's exact test as appropriate.

Results For the main endpoint (community hospital presentation to wire-crossing time), the "after" period was associated with significantly shorter times (105 *vs.* 205 minutes, $p = 0.0001$). Part of the time savings were achieved by faster HEMS dispatch (from 35 to 16 minutes, $p = 0.0004$), and further time savings were accrued by streamlining time intervals between HEMS dispatch and PCI center arrival (from 56 to 45 minutes, $p = 0.002$). Additional time savings occurred after arrival to the PCI center; receiving center arrival to wire-crossing times decreased from 91 to 29 minutes ($p = 0.0001$). Of the decrease in total time, 37% (36 minutes) was due to some combination of improved efficiency in STEMI diagnosis, HEMS dispatch, and pretransport stabilization. The remaining 63% of time savings was accrued by a combination of bypassing the receiving center ED, simultaneous cath lab activation (at time of HEMS dispatch), and optimization of lab procedures. The proportion of patients with door to wire-crossing times <90 minutes increased from 0% to 24% ($p = 0.0001$), and the % with times <120 minutes increased from 2% to 67% ($p = 0.0001$). There were no significant differences between the before and after periods, with regard to the following patient outcomes: death ($p = .28$), urgent revascularization ($p = .62$) or hospital length of stay ($p = .46$).

Authors' conclusions In a rural setting the goal of treating STEMI patients within 90 minutes can be achieved for some transfer patients given a rapid diagnosis, triage, and transfer system.

Commentary This study has particular strengths in its clear demonstration of time savings at a number of steps in the diagnosis/transfer process, with potential for clinical significance. While the lack of identification of any health outcomes benefits is appropriately highlighted in the authors' discussion, it is hard to dispute the criticality of the STEMI care surrogate endpoints relating to time. Considering the lack of downside to the types of protocol changes that were adopted by the authors (and which have been previously described by other HEMS services)[18] there seems sufficient evidence to support broader application of these streamlining principles. In addition to the lack of mortality benefit, there were other limitations to the study. Perhaps most importantly, although 14 community hospitals received training in STEMI stabilization and transport streamlining, the final data analysis excluded 6 hospitals since they cumulatively accounted for only 22 transports. Thus, the "real-world" generalizability of the study results may be lessened, since it is not uncommon for a significant proportion of any HEMS service's transports to come from relatively infrequent users.

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