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Helicopter EMS Transport Outcomes Literature: Annotated Review of Articles Published 2012-2013

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Review Article

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ABSTRACT

Helicopter EMS (HEMS) and its possible association with patient-oriented 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, review articles covering HEMS outcomes studies from 1980-2000, for both non trauma and trauma, were published in 2002. The project was extended with subsequent reviews covering the literature through 2011. This review continues the series, outlining outcomes-associated HEMS literature for 2012-2013.

Keywords: Helicopter emergency medical service; cardiac; cost-effectiveness; trauma.

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1. 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 outlined the HEMS outcomes-related literature for trauma and non trauma diagnoses published through 2000 [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 was updated with subsequent publications that covered articles published during the years 2000-2003, [3] 2004-2006, [4] and 2007-2011 [5]. The current paper aims to extend the previous reviews, assessing outcomes studies published in 2012 and 2013. As with earlier reviews in this 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 applicable time frame as an aid to those who wish to explore the evidence basis for HEMS use. The overarching purpose of this review is to provide a compendium of HEMS outcomes literature, to serve as a basis for reference for any interested parties researching the question of whether air medical transport improves patient outcomes. The intent is neither to provide a comprehensive listing of all studies with potential relevance to HEMS outcomes, nor to provide comprehensive analysis of each study that is included. Furthermore, this is not intended as a meta-analysis or similar assessment (*e.g.* we did no assessment for the potential for publication bias).

2. MATERIALS AND METHOD

A computerized literature search was performed as outlined in previous published reviews [5]. The same databases and general approach was used for the current review. The search database was the National Library of Medicine's MEDLINE (online Index Medicus). The search was conducted with the following terms: helicopter, helicopter emergency, helicopter emergency medical service(s), helicopter transport, helicopter trauma, helicopter EMS, helicopter vs. ground, air medical, air medical transport, HEMS, emergency helicopter, helicopter transport trauma, transport helicopter. Additional searches included author searches based on publications known to the review's authors. The search, which was never intended to be fully comprehensive (see discussion below), returned over 12,000 results. Most of the results were quickly discarded based upon review of title. Subsequently, approximately 100 abstracts were reviewed in order to select the final set of publications.

In terms of focusing the current review, it must be acknowledged that when assessing a broad literature base, there are many "gray areas" and a strict definition of which studies to include is simply not possible. The "inclusion criteria" (*i.e.* direct addressing of HEMS-associated patient-centered outcome) are admittedly subjective, and also admittedly imperfect—but there is no easily defined set of criteria that would satisfy all circumstances and needs. Some excellent studies with indirect "outcomes" were excluded. The primary example of these exclusions was time-based studies. There were at least six important studies [6-10] that demonstrated real or theoretical time savings associated with HEMS transport of time-critical illness, that were not included in this review since they did not specifically tie time benefits—known to be generally important—to specific incremental outcome improvement. A time-based study (see below) that did tie time savings to outcomes improvement was included in the review.

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. This review is not intended to be a fully comprehensive treatise. While it is not possible to enumerate articles that were missed, examples of studies that would likely have been missed include those that were not indexed in MEDLINE, and those published in languages other than English.

The papers that are included in this review did not include papers that were solely “time-savings based” studies that did not tie time savings with outcomes improvement. The studies that were included are categorized into diagnostic areas. 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 [11]. Within categories, articles are listed chronologically with earlier papers first.

One paper that is noteworthy but not discussed here—because it is a review in and of itself—is the Cochrane review of HEMS for scene response [12]. This review, which was first published in 2013, is characterized by complexities that preclude its easy summary here. The Cochrane review (co-authored by one of this review’s authors) is currently being updated to include studies published since the review’s initial preparation (the first version of the Cochrane review included only studies published through 2011). Readers who wish a methodologically detailed assessment of all of the HEMS trauma scene response evidence are referred to that Cochrane review. Many of the studies mentioned in this review are also mentioned in the Cochrane review, with the primary difference for this review being its extension of focus beyond scene trauma.

3. CARDIAC [13,14]

3.1 Phillips M, Arthur AO, Chandwaney R, Hatfield J, Brown B, Pogue K, Thomas M, Lawrence M, McCarroll M, McDavid M, Thomas SH. Helicopter transport effectiveness for patients being transported for primary percutaneous coronary intervention. Air Med J. 2013;32:144-152 [13].

3.1.1 Objective

The study goals were to first assess logistics/time advantages offered by HEMS as compared to ground transport of STEMI patients for primary PCI, and then to translate time savings calculations in mortality benefit estimates.

3.1.2 Method

3.1.2.1 Study design

This was a retrospective consecutive-case review. The methods called for use of advanced geographic information software (GIS) to calculate alternate-mode transport times for whichever transport mode was not used in a given case.

3.1.2.2 Setting

The study was set at a tertiary cardiac receiving center (Oklahoma Heart Institute in Tulsa, Oklahoma).

3.1.2.3 Time frame

Study patients were transported January 2010 through June 2011.

3.1.2.4 Patients

Eligible patients were those who had STEMI diagnosis and who underwent air or ground EMS interfacility transport from an ED to the Oklahoma Heart Institute. There were 97 patients (66 air and 31 ground).

3.1.3 Result

The speculative nature of the study translated into a number of different results calculations being reported; each calculation was based upon different assumptions about tying pre-PCI time savings to mortality benefit. Among the study's main results was a finding that there were 1.7 lives saved per 100 transports, solely due to time savings accrued with HEMS use. Among the other results were a finding that, for those patients who did go by ground EMS, use of HEMS would have doubled the proportion of cases reaching PCI within 120 minutes of initial hospital presentation; in 9 out of 10 cases HEMS time savings was calculated to have surpassed the *a priori*-defined clinically significant margin of 15 minutes. For the 6 ground-transported cases in which HEMS was documented to be unavailable due to weather, zero patients made it to PCI within 120 minutes; calculations estimated that 4/6 of these patients would have made it to PCI within 120 minutes if helicopter transport had been used.

3.1.4 Authors' conclusions

Based solely upon considerations of time savings, and using the cardiology literature's estimates correlating earlier primary PCI with mortality improvement, HEMS use saved a clinically significant 1.7 lives per 100 transports (number needed to transport to save one life, 59).

3.1.5 Commentary

This paper, written by some of those preparing this review, had a number of weaknesses that severely limit its application. Those limitations fall largely into one of three categories. First, there are limitations to the use of "estimated times" for non-used modes of transport. Second, there is something of a leap of faith required to tie the time savings surrogate endpoint to the meaningful endpoint of mortality improvement. Third, there could be mechanisms that HEMS can impact mortality (and morbidity) that are not accounted for in a study focusing solely on times. These three areas of limitations are discussed in detail in the paper. The authors' overall conclusions are that the data should serve as the basis for a larger analysis (which is now ongoing) to assess whether the "NNT" of 59 is consistently estimated in different areas. If the results of the initial study are replicated in the larger *n* analysis, the NNT of 59 begins to approach utility as a variable in the cost-effectiveness analyses that are so important for HEMS and policy-makers [12].

3.2 Hesselfeldt R, Pederson F, Steinmetz J, Vestergaard L, Simonsen L, Jorgensen E, Clemmensen P, Rasmussen LS. Implementation of a physician-staffed helicopter: Impact on time to primary PCI. Euro Intervention. 2013;9:477-483 [14].

3.1.1 Objective

The study aim was to compare HEMS and ground STEMI patients transported for primary PCI, with the goal of determining whether HEMS transport impacted the primary endpoint of time-to-PCI.

3.1.2 Method

3.1.2.1 Study design

This was a prospective, observational analysis of logistics and clinical outcomes (i.e. 30-day and 1-year mortality).

3.1.2.2 Setting

The single-site study was set at a tertiary cardiac receiving center (Copenhagen University Hospital). The study country implemented a physician-staffed HEMS unit in May 2010 (the initial month of a 12-month HEMS data collection period for this study); HEMS coverage extended to the eastern part of Denmark with a coverage area of 185 km from Copenhagen.

3.1.2.3 Time frame

Study patients were transported during a 12-month (HEMS) or 16-month (ground EMS) period in 2010 and 2011.

3.1.2.4 Patients

Eligible patients were those who had STEMI diagnosis and who underwent air or ground EMS scene or interfacility transport from a location outside of 30 minutes' driving distance from the study center. There were 450 patients (114 air with 93 from scene and 21 interfacility; and 336 ground with 208 scene and 128 interfacility). In terms of baseline and procedural characteristics (e.g. Killip classification, coronary artery flow grades), the air and ground groups were statistically indistinguishable.

3.1.3 Result

The primary endpoint of time from initial EKG diagnosis to arrival at the PCI suite, was reduced in HEMS as compared to ground transported patients. The degree of reduction was significant, both statistically ($p=.01$) and clinically (median HEMS time to PCI of 84 minutes as compared to median ground EMS time of 104 minutes). The time from initial EKG to balloon deployment was similarly reduced for HEMS (114 versus 132 minutes, $p<.01$). There were no differences in receiving center door-to-balloon times. Although the point estimates for mortality improvement were in favor of HEMS for both 30-day and 1-year mortality, the survival rates for air and ground transport groups were not statistically different

at either the time point of 30-day mortality (HEMS 2.6% versus ground 6.3%, $p=.14$), or 1-year mortality (HEMS 6.7% versus ground 9.9%, $p=.35$).

3.1.4 Authors' conclusions

The time to PCI was reduced with use of HEMS for patients outside a half-hour driving radius.

3.1.5 Commentary

In an era of increasing understanding of the importance of time as a surrogate endpoint, studies such as this one provide useful contributions to the debate as to if and when HEMS may be integrated as part of cardiac care systems. The relatively low numbers—compared to the very large datasets used to define the importance of time as an independent STEMI care endpoint—likely contributed to the failure to identify a mortality benefit for HEMS. The authors point out that their study was not intended to be a rigorous analysis of mortality benefit; it was rather a time-based study with the time savings as the main endpoint. It is noteworthy that the point estimates for mortality reduction were indeed in favor of HEMS—but not statistically significant—in this study. Using similar mortality difference (i.e. 6.3% versus 2.6% for 30-day mortality) in *post hoc* power calculations, it is straightforward to estimate that >1400 patients would be needed to achieve 90% power to identify as significant, the substantial relative reduction in mortality (i.e. nearly 60%) denoted in this study's 30-day survival results. With these limitations in mind, the study represents an important contribution to the evidence base, and suggests a time cutoff (i.e. 30 minutes' ground transport time) for STEMI care systems designing logistics triggers for HEMS use for primary PCI.

4. COST-EFFECTIVENESS [15,16]

4.1 Taylor C, Jan S, Curtis K, Tzannes A, Li Q, et al. The cost-effectiveness of physician-staffed Helicopter Emergency Medical Service (HEMS) transport to a major trauma centre in NSW, Australia. Injury. 2012;43:1843-1849 [15].

4.1.1 Objective

The study goal was to assess cost-effectiveness of HEMS trauma transport from scenes to Level 1-equivalent trauma centers, as compared to ground transport to trauma center or ground transport to non-trauma hospitals followed by secondary (ground or air) transfer to the trauma center.

4.1.2 Methods

4.1.2.1 Study design

This was a true cost-effectiveness study that first calculated adjusted estimates of in-hospital mortality using logistic regression. Adjusted hospital costs were estimated through a general linear model incorporating a gamma distribution and log link. These estimates along with other assumptions were incorporated into a Markov model with an annual cycle length to estimate a cost per life saved and a cost per life-year saved at one year and over a patient's lifetime respectively in three patient groups (all patients; patients with serious injury as defined by ISS>12; TBI patients).

4.1.2.2 Setting

The study was set at a tertiary receiving center (St. George Hospital) in NSW, Australia.

4.1.2.3 Time frame

Study patients were transported over an 11-year time frame, 2000-2010.

4.1.2.4 Patients

Eligible patients were drawn from the study *n* of 10,180 and constituted one of the three groups of cases as outlined above (all trauma; ISS>12; TBI).

4.1.3 Results

The main results showed HEMS to be more costly but more effective at reducing in-hospital mortality; cost (in Australian dollars, which roughly approximate \$US) per life saved for the three study groups: all patients—\$1,566,379; ISS>12—\$533,781; TBI patients—\$519,787. When modelled over a patient's lifetime, the improved mortality associated with HEMS led to a cost per life year saved of \$96,524, \$50,035 and \$49,159 in the three patient groups respectively. Sensitivity analyses revealed a higher probability of HEMS being cost-effective in patients with serious injury and TBI.

4.1.4 Authors' conclusions

The investigation confirms a HEMS intervention is associated with improved mortality in trauma patients, especially in patients with serious injury and TBI. The improved benefit of HEMS in patients with serious injury and TBI leads to improved estimated cost-effectiveness.

4.1.5 Commentary

The authors' conclusions place physician-staffed HEMS use well within the commonly accepted margin for cost-effectiveness, of about \$100,000 per life-year [16]. In fact, the current study is consistent with the model-based analysis of Delgado that is included in this review as a major contribution—although not, strictly speaking, an “outcomes study”—to the HEMS literature, that should be reviewed by anyone with interest in HEMS cost-effectiveness (see below). The results from the Taylor study are actually generally consistent with other estimates for cost-effectiveness, with a few noteworthy points. First, the authors calculated the endpoint in terms of life-years, rather than the (preferred) quality-adjusted life-years (QALYs). Second, the cost-effectiveness for the overall population was acceptable, but there was even higher cost-effectiveness at a cutoff for “severe” injury of ISS>12 (not ISS>15 as is often used). Third, it is not clear to what degree the authors' conclusions should be extrapolated to non-physician HEMS services.

4.2 Delgado MK, Staudenmayer KL, Wang NE, Spain DA, Weir S, Owens DK, Goldhaber-Fiebert JD. Cost-effectiveness of helicopter versus ground emergency medical services for trauma scene transport in the United States. Ann Emerg Med. 2013;62:351-362 [16].

4.2.1 Objective

The study goal was to determine the mortality reduction that must be achieved by HEMS, in order to offset the costs, risks, and inevitable overtriage problems associated with air medical transport.

4.2.2 Method

4.2.2.1 Study design

This was a rigorously executed cost-effectiveness study. The investigators used decision analysis modeling and focused on scene transport for trauma. The design was quite complex, as such designs must necessarily be in order for them to produce meaningful results. In brief, the investigators used a Markov model approach and incorporated data from a number of sources (e.g. National Trauma Data Bank), to apply their model to a population of injured patients from the time of scene response through their lifetimes.

4.2.2.2 Setting

The study was executed using patient data generated from the U.S.

4.2.2.3 Time frame

Study patients were transported over varying time frames, depending on the specific source of patients incorporated into the model (e.g. the National Trauma Data Bank patient set used was from the 2010 sample).

4.2.2.4 Patients

Eligible patients were those aged 18-85 at the time of trauma, who were transported from the scene by either air or ground EMS, with patient information being drawn from previously noted sources.

4.2.3 Result

The main result was that HEMS needs to provide a 15% relative reduction in mortality for patients with serious injuries, in order for air medical transport's costs to fall below the pre-specified threshold of \$100,000 per quality-adjusted life-year (QALY). The 15% relative reduction translated to an absolute mortality reduction of 1.3%; HEMS is cost-effective using the QALY threshold of \$100,000/QALY, if air medical transport saves 1.3 lives per 100 transports. The cost-effectiveness of HEMS was found to be sensitive to helicopter overtriage rates. Overtriage to air medical transport of 9% to 69% (a range selected from literature-provided overtriage rates) correlated with "cut-point" mortality reduction rates of 11% to 26% that determined cost-effectiveness at \$100,000/QALY. Other detailed results provided in the study include such findings as the model's substantial sensitivity to long-term

disability, and the relative lack of vehicle safety (*i.e.* crash) probability changes on model estimates.

4.2.4 Authors' conclusions

To be cost-effective for scene trauma response, HEMS must demonstrate a mortality reduction of at least 15% (or 1.3 lives saved per 100 missions). Given the uncertainties inherent in HEMS application and the modeling approach employed, a 95% certainty of cost-effectiveness is achieved only if HEMS is associated with saving 2.7 lives per 100 missions.

4.2.5 Commentary

This study did not evaluate, *per se*, an “outcome” endpoint in evaluating how many lives HEMS saves. The authors did not focus their efforts on the question “*Does HEMS save lives*” but rather asked the equally important (and usually neglected) question “*How many lives must HEMS save to be cost-effective?*” In drawing patients and data from a variety of sources, and in carefully explaining and exploring the multiple assumptions required by a complex modeling process, the authors have given the HEMS community a meticulous, reasoned, and defensible model design process. The study's estimates have given HEMS researchers a solid starting place for the important process of defining and assessing HEMS cost-effectiveness.

5. NEUROLOGY AND NEUROSURGERY [17]

5.1 Olson MD, Rabinstein AA. Does helicopter emergency medical service transfer offer benefit to patients with stroke? *Stroke*. 2012;43:878-880 [17].

5.1.1 Objective

The study goal was to assess whether air versus ground transport of ischemic stroke patients who were post-thrombolysis, was associated with reduction of complications or improvement in clinical outcomes.

5.1.2 Methods

5.1.2.1 Study design

This was a retrospective consecutive-case review.

5.1.2.2 Setting

The study was set at a tertiary receiving center (Mayo Clinic, in Minnesota).

5.1.2.3 Time frame

Study patients were transported between 2002 and 2010.

5.1.2.4 Patients

Eligible patients were those who had ischemic stroke diagnosis and institution of thrombolytic therapy, prior to transport. There were 122 patients (94 air and 28 ground).

5.1.3 Results

The main results were a lack of finding of intra-transport or post-transport incidents and outcomes differences, between the air and ground EMS groups. Time from activation to arrival at the receiving center, was significantly shorter in the air-transported patients (53 versus 68 minutes).

5.1.4 Authors' conclusions

There were no differences in transport events, post-transport events, or overall outcomes associated with air versus ground transport of post-tPA stroke patients. Ground transport should be considered for these patients, unless they are being considered for time-critical rescue therapy (e.g. emergency endovascular intervention).

5.1.5 Commentary

The authors' statement that savings of 15 minutes doesn't matter in patient who have already received time-windowed therapy (tPA), is supported by their data and by common sense. Few, if any, experts in HEMS or stroke have advocated use of air transport post-tPA when there is no time-windowed therapy at the receiving end. Of course, it is not always easy to know who will need rescue therapy (including neurosurgical intervention for thrombolysis complications), and the routine use of ground EMS incurs some low-but nonzero-risk that time lost will translate into outcomes worsening.

For those patients who may have an extra 15 minutes of cerebral ischemia before rescue therapy such as thrombolysis, though, the data are clear: Each 15 minutes' time loss is associated with a 4% increase in mortality and a 3% increase in worse neurological outcome for survivors [18]. For some patients, time really is brain; the proper selection of these patients is the key to judicious HEMS use for neurological conditions.

6. TRAUMA-SCENE AND INTERFACILITY COMBINED POPULATION [19,20]

6.1 Rhinehart ZJ, Guyette FX, Sperry JL, Forsythe RM, Murdock A, Alarcon LH, Peitzman AB, Rosengart MR. The association between air ambulance distribution and trauma mortality. *Ann Surg.* 2013;257:1147-1153 [19].

6.1.1 Objective

The study's goal was to determine whether increasing distance between HEMS bases and home residence or referring facility, is associated with increasing trauma mortality.

6.1.2 Methods

6.1.2.1 Study design

This was a retrospective cohort analysis. The design used a geographic information software (GIS) approach to generate distances which were used in multivariate modeling. Multivariate regression adjusted for a breadth of potential logistic, systems, and patient-related confounders.

6.1.2.2 Setting

The study was population-based, in the state of Pennsylvania.

6.1.2.3 Time frame

Study patients were those transported during the decade 1997-2007.

6.1.2.4 Patients

The study included scene and interfacility-transports of adults (>15), by ground or air, to any level I or II trauma center in the state.

6.1.3 Results

The results included discussion of logistics and changes over time, of a variety of factors (e.g. scene vs interfacility case mix, injury acuity). For purposes of this review, the major results were that there was a positive and statistically direct and strong association between mortality and scene trauma geographic location and a “close” HEMS base, with the cutoff for “close” defined at 11 miles’ distance. For patients residing more than 20 miles from a trauma center, increasing distance from an airbase is associated with increasing risk of death

6.1.4 Authors’ conclusions

Proximity to an airbase is associated with improved mortality for scene-transported trauma patients when the injury scene was more than 11 miles’ distance from a trauma center. While the benefit was statistically significant starting at 11 miles’ distance, it became clinically significant at 20 miles’ distance from the trauma center (1% mortality worsening per mile, for increasing distance from trauma scene to airbase location). The association between HEMS proximity and improved outcome remained present when analysis adjusted for acuity and other parameters. There was no benefit to proximity to multiple airbases, and there was no benefit to airbase proximity for interfacility transports.

6.1.5 Commentary

The study took an interesting approach, of using “distance to helicopter base” as a surrogate for air medical services availability, and then assessing whether proximate HEMS improved trauma outcome. The finding that having a nearby HEMS base was positively associated with trauma outcome is a suggestive, although admittedly coarse, indicator of the positive impact HEMS has on trauma outcomes. Of course, having a HEMS base nearby doesn’t always mean that the aircraft will be stationed at the base (or available if stationed there),

and some analyses are probably weakened by the use of the patient's home address as a surrogate for injury location.

Methodologic limitations (e.g. use of surrogate endpoint of distance as stand-in for actual HEMS use) notwithstanding, over a large cohort such as the one in this study, the power of numbers is compelling. The authors' detailed statistical analysis included accounting for many potential confounders, although it does remain possible that helicopter availability is a surrogate for better-developed trauma systems. The study's fascinating natural experiment design, based upon the proliferation of the HEMS services in Pennsylvania, does seem to negate many of these potential confounders. Furthermore, the authors' conclusion is in line with common sense: If one is more than about 20 miles from a trauma center then having a helicopter nearby is coarsely associated with improved trauma mortality.

6.2 Hesselfeldt R, Steinmetz J, Jans H, Jacobsson ML, Andersen DL, Buggeskov K, Kowalski M, Praest M, Ollgaard L, Hoiby P, Rasmussen LS. Impact of a physician-staffed helicopter on a regional trauma system: A prospective, controlled, observational study. Acta Anesthesiol Scand. 2013;57:660-668 [20].

6.2.1 Objective

The study's aims were to assess results in a trauma system, of adding a physician-staffed HEMS unit. The main study hypothesis was that HEMS would reduce time from injury to definitive care (but the study also assessed mortality).

6.2.2 Method

6.2.2.1 Study design

This was a natural experiment design, in the sense that a 5-month period before, and a 12-month period after, HEMS implementation was assessed.

6.2.2.2 Setting

The study was conducted in Denmark.

6.2.2.3 Time frame

Study patients were transported in the 5-month period prior to HEMS implementation (December 2009 through April 2010) and during the 12-month period after HEMS implementation (May 2010 through April 2011).

6.2.2.4 Patients

The study included all trauma patients treated by the trauma team at 7 receiving centers in Denmark; the study *n* was 1788 (204 had ISS>15).

6.2.3 Result

The study results included a finding of absolute reduction of 16% (from 50% pre-HEMS to 34% post-HEMS, $p=.04$) in the endpoint of secondary transfers of high-acuity trauma patients (in other words, they were transported directly from the scene to the trauma center). The median delay to definitive care was also reduced, from 218 minutes to 90 minutes ($p<.01$). Most importantly, 30-day mortality was reduced from 29% to 14% ($p=.02$).

6.2.4 Authors' conclusions

Implementation of the physician-staffed HEMS unit was associated with significant reduction in important endpoints such as time to definitive care, secondary transfer, and 30-day mortality.

6.2.5 Commentary

The study adds to the natural-experiment evidence—likely among the closest the HEMS world will get to randomized trials—that HEMS improves outcomes. Of course, a natural experiment design is not a randomized controlled trial, and it seems possible that other factors (e.g. improved trauma care overall) occurred simultaneously with the introduction of HEMS into the picture. With that *caveat*, the doubling (risk ratio 2, 95% CI 1.13 to 3.54, $p=.02$) of survival for the ISS>15 group translates into a number-needed-to-treat of only 7 such patients, to save one life.

7. TRAUMA–SCENE TRANSPORTS [21-28]

7.1 Bulger EM, Guffey D, Guyette FX, MacDonald RD, Brasel K, et al. Impact of prehospital mode of transport after severe injury: A multicenter evaluation from the Resuscitation Outcomes Consortium. J Trauma. 2012;72:567-575 [21].

7.1.1 Objective

The study's goal was to determine whether transport mode was associated with outcomes differences in severely injured trauma patients transported from the scene.

7.1.2 Method

7.1.2.1 Study design

This was a retrospective review of cases accrued for study in a prehospital fluid resuscitation project. The design was thus a secondary analysis of data collected for another research project (*i.e.* not an analysis of administrative data).

7.1.2.2 Setting

The trauma centers in the study were 10:8 in the U.S. (Level I centers) and 2 in Canada (described by the authors as equivalent to Level II U.S. centers).

7.1.2.3 Time frame

Study patients were those transported during 2006-2009.

7.1.2.4 Patients

The study included 703 air and 1346 ground transported patients who were at least 15 years in age, transported from trauma scenes. Exclusions included reception of at least 2000mL of fluid before transport, as well as “non-severe” trauma. Severe trauma was defined as being hypovolemic shock (SBP less than 70 or SBP less than 90 with HR at least 109) or severe TBI (GCS<9) or both; these three groups (Shock+TBI, TBI-only, Shock-only) comprised the three main study cohorts.

7.1.3 Result

The HEMS patients were more likely to be blunt trauma victims, more likely to be in the TBI cohort, and had a lower GCS with higher ISS (and New ISS). HEMS patients had lower TRISS probability of survival (P_s). Overall, the confidence intervals for the multivariate analyses of outcomes association with transport mode all crossed the null value. For the Shock+TBI cohort, HEMS' point estimate for 28-day survival improvement was 1.11 with 95%CI 0.82-1.51. For the Shock-only cohort, the HEMS survival improvement point estimate was 1.31(95%CI 0.76-2.25). For the TBI-only cohort, the HEMS survival improvement point estimate was 0.91(0.63-1.33). Despite being (far) more severely injured, HEMS patients were less likely than ground EMS patients to be acidotic upon trauma center arrival.

7.1.4 Authors' conclusions

In the current study, there was no difference in outcome between ground and air transport suggesting that either approach may be appropriate and that air medical services, implemented in the manner observed in these randomized controlled trials, may overcome limitations of distance and access to specialty care.

7.1.5 Commentary

The study grew out of well-conducted analyses of pre hospital fluid resuscitation. Like many secondary analyses, the study has weaknesses related to its assessment of data for endpoints other than those intended (and planned-for) in the original design. Most notably, the study is distinctly underpowered to identify as significant, any point estimate suggesting mortality differences (see below). Exclusion of patients receiving 2000 mL fluid before transport would preferentially eliminate HEMS patients, thus risking selection bias. Furthermore, missing data were potentially problematic; there is little detail provided on the multiple imputation techniques used to deal with these inevitably tricky problems. An additional problem was the lack of adjustment for the critical variable of transport distance, which would obviously be greater for HEMS patients.

There is something in this paper for both sides of the HEMS debate. For the “HEMS doesn't improve outcome” crowd—which clearly includes those writing the editorial discussion appearing just after the paper—there is the overall negative result in multivariate analysis. Upon closer examination, however, the authors' own conclusion (see above) appears more appropriate. Not only was there the potential for methodologic shortcomings accounting for the negative p values despite point estimates favorable to HEMS (e.g. 31% outcomes

improvement point estimate for HEMS transport of shock-only patients), but the TRISS results also were favorable. For two of the three study cohorts (Shock+TBI and TBI-only) there was a statistically significant difference between TRISS-predicted mortality in HEMS and ground EMS groups. In both of these cohorts, the actual mortality was statistically similar. Thus, HEMS allows for patients with statistically lesser chance of survival, to reach actual survival rates equal to those of lesser-acuity ground EMS patients. This finding renders more reasonable the conclusion of the authors about the potential value of HEMS.

7.2 Galvagno SM, Haut ER, Zafar SN, Millin MG, Efron DT, et al. Association between helicopter versus ground emergency medical services and survival for adults with major trauma. JAMA. 2012;307:1602-1610 [22].

7.2.1 Objective

The study's goal was to determine whether transport mode was associated with differences in mortality (during index hospitalization) in severely injured trauma patients transported from the scene.

7.2.2 Methods

7.2.2.1 Study Design

This was a retrospective analysis of data from the National Trauma Data Bank (NTDB).

7.2.2.2 Setting

The NTDB patients comprising the study set were cared for at U.S. level I and II trauma centers. NTDB does not include information on the crew configuration of HEMS programs providing transports.

7.2.2.3 Time Frame

The study used NTDB data from the commencement in 2007, of new NTDB data gathering methods that optimized data quality. Patients were those who were in the NTDB from 2007 through 2009.

7.2.2.4 Patients

Adult patients (at least 18) transported from the scene by ground ($n=161,566$) or HEMS ($n=61,909$) to Level I or Level II trauma centers. Patients who died in the ED were excluded from analysis.

7.2.2.5 Analysis

The analysis was quite complex, involving generation of many logistic regression models and incorporating varying treatments for missing data. Propensity scores, cluster analysis (by trauma center), and sensitivity analyses were among the advanced statistical techniques used; logistic regression diagnostics were also calculated.

7.2.3 Results

In the most conservative model (propensity scored logistic regression), the odds ratio for HEMS association with mortality improvement was 1.16 (95%CI 1.14 to 1.17, $p < .001$) for Level I center-bound patients, and 1.15 (95%CI 1.13 to 1.17, $p < .001$) for patients taken to Level II centers; both findings were significant in logistic regression calculations with favorable model performance characteristics. The “number needed to transport” to save a life, was 65 for Level I and 69 for Level II centers. This corresponded to an absolute mortality reduction of 1.5% for Level I trauma center patients and 1.4% for Level II trauma center transports.

7.2.4 Authors' Conclusions

In patients with ISS at least 15 (who are hard to identify at the time of triage), HEMS is associated with significant mortality improvement. Further studies should use the mortality results as a starting point for cost-effectiveness calculations, but these studies should also include non mortality benefits of HEMS. Incorporation of distance (not possible in the current study due to NTDB limitations) as an instrumental variable is recommended for future studies assessing the association between HEMS and trauma outcomes.

7.2.5 Commentary

This study, arguably one of the most methodologically complete in the HEMS literature, clearly demonstrated outcomes improvement for HEMS transport of those with ISS at least 15. The authors' discussion includes detailed explanation of the fine-tuned approach to NTDB data use, and there are also many points in the discussion on NTDB limitations (e.g. lack of reliable information on distance, time, or crew configuration). Every logistic regression model generated in the study demonstrated a significant association between HEMS transport and trauma outcome. The authors made a case that there were other, unmeasured but nonetheless potentially important, likely HEMS benefits besides mortality. The authors acknowledge the limitations due to lack of full data availability on patient disposition, and also point out that the data do not address the critical question of triage. The study's acknowledgment of the current inability to prospectively define which patients will have ISS > 15, is quite useful for inclusion in such a major journal (JAMA); despite the seemingly obvious nature of the overall trauma triage problem it is elided in many discussions of HEMS (over)use that seem to expect precision in HEMS triage, when there remains substantial imprecision in simply determining who needs trauma center care.

7.3 de Jongh M, van Stel H, Schrijvers A, Leenen L, Verhofstad M. The effect of Helicopter Emergency Medical Services on trauma patient mortality in the Netherlands. Injury. 2012;43:1362-1367 [23].

7.3.1 Objective

The study's goal was to evaluate the effect of Helicopter Emergency Medical Services (HEMS) on trauma patient mortality and the effect of pre hospital time on the association between HEMS and mortality.

7.3.2 Method

7.3.2.1 Study Design

This was a retrospective matched-pair cohort study.

7.3.2.2 Setting

The study patients were cared for in the Netherlands (Tilburg).

7.3.2.3 Time Frame

Patients were drawn from the hospital's admissions 2003 to 2008.

7.3.2.4 Patients

The study included all trauma patients treated by EMS, assisted by HEMS, and admitted at the study hospital (St. Elisabeth) during the designated time period ($n=186$ in the HEMS group and same number in the ground EMS-only group). Patients presenting directly to St. Elisabeth by non-EMS means, and those transferred from another hospital, were excluded.

7.3.2.5 Analysis

The study first accrued patients meeting the HEMS cohort criteria, and then matched ground EMS-only patients on age, ISS, gender, severe TBI (AIS at least 4), and mechanism. Age and ISS were categorized before matching; physiology (RTS) was adjusted for in the regression analysis but not matched upon. Pearson chi-squared tests were used to compare categorical variables, Independent t-tests were used to compare linear continuous variables, and Mann-Whitney tests were used to compare non-linear continuous data. The comparison for treatment by HEMS and EMS was made for both traumatic brain injury (TBI) patient group as well as the group without TBI.

7.3.3 Results

The odds ratio of in-hospital mortality of patients treated by HEMS and EMS compared to those treated by EMS only was 1.0 for the total study population, 1.3 for patients with TBI and 0.9 for patients without TBI, respectively. These numbers show a number needed to treat (NNT) of 22 TBI via HEMS to allow 1 additional patient to survive one calendar day after initial trauma compared to patients without HEMS transport. For patients without TBI, 272 patients need to be treated by the HEMS to save one additional life in the first calendar day. The HEMS NNT to survive the hospital admission is minus fifteen for patients with TBI and 129 for patients without TBI. After adjusting for the time between the trauma and patient arrival at the ED, the risk of early trauma fatality for TBI patients treated by the HEMS decreased from an odds ratio of 0.8 to an odds ratio of 0.6. The risk of in-hospital mortality for TBI patients treated by the HEMS decreased from an odds ratio of 1.3 to an odds ratio of 0.8.

7.3.4 Authors' conclusions

The data in the present study cannot prove the benefit of HEMS in the Netherlands.

7.3.5 Commentary

Matching is a difficult analytic approach; the potential for difficulties (e.g. residual confounding by RTS and intubation status as in this paper) is great. In this paper, the matching clearly failed and the study is left with a standard problem in the HEMS trauma literature: having to try and adjust for markedly different patient acuity as assessed at the time of transport. The problems with this study include many methodological issues, only some of which are mentioned here. The study *n* was too low to include all of the relevant covariates in a multivariate model (20 outcomes per covariate is the usual requirement), which is presumably why matching was required. The small study *n* also translated into very wide CIs: The point estimates for both all-patient and TBI-patient were both consistent with the overall HEMS literature numbers (OR of 0.8) but the CIs for both endpoints were indicative of low power (0.4-1.7 for all patients; 0.2 to 3.3 for TBI). When considered in comparison to the numerous studies from the Netherlands (assessing essentially the same sorts of population) that found similar point estimates but with statistical significance,[29-31] the impact of this paper on the literature is uncertain.

7.4 Desmettre T, Yeguiayan JM, Coadou H, Jaquot C, Raux M, Vivien B, Martin C, Bonithon-Kopp C, Freysz M. Impact of emergency medical helicopter transport directly to a university hospital trauma center on mortality of severe blunt trauma patients until discharge. Crit Care. 2012;16:R170 [27].

7.4.1 Objective

The study's goal was to analyze the effect of HEMS on scene trauma patient survival outcomes.

7.4.2 Method

7.4.2.1 Study Design

This was a retrospective medical records review.

7.4.2.2 Setting

The study was conducted in France. HEMS crews included physicians with emergency medicine expertise, who worked at trauma centers; ground EMS patients were transported by physicians with lesser experience and expertise.

7.4.2.3 Time Frame

Patients were transported between December 2004 and March 2007.

7.4.2.4 Patients

The study comprised 1,958 adult (>18) blunt trauma patients; 74% were transported by ground EMS and 26% by HEMS. Patients were included if they had "severe" blunt trauma, as defined by ICU admission or ICU team care (*i.e.* prior to in-hospital death before ICU admit).

7.4.2.5 Analysis

The study used multivariate logistic regression methods, including interaction terms between transport mode and multiple anatomic and physiologic variables.

7.4.3 Results

After adjustment, trauma survival was greater in the HEMS group (OR 1.47; 95%CI 1.02 to 2.13; $p=.035$). Patients treated by HEMS crews were more likely to be treated aggressively with interventions such as endotracheal intubation, administration of fluids, treatment with vasopressors, and blood product transfusion.

7.4.4 Authors' Conclusions

HEMS scene dispatch was associated with beneficial impact on mortality for patients with severe blunt trauma. Whether the association was due to improved care or logistics needs to be more thoroughly assessed.

7.4.5 Commentary

The study used a solid methodology, and adjusted for potential confounders of the transport mode-outcome association. The analysis included such admirable details as logistic regression diagnostics such as goodness-of-fit testing (often skipped in reports of HEMS logistic regression studies). The median injury severity of the study patients was fairly high (25 for ground EMS and 26 for HEMS), and the definition of "severe blunt trauma" (by ICU care) was practical. That said, the *ex post facto* determination of which patients had "severe injuries" means that the study results distinctly support HEMS outcome benefit while not strongly supporting any particular set of triage criteria. This is not necessarily a study weakness, but rather a characteristic of the study's goals. One noteworthy contribution of the study is its inclusion of discussion (and statistical demonstrations) surrounding the performance of pre hospital critical care interventions by the more highly trained HEMS physicians as compared to ground EMS physicians.

7.5 Rose MK, Cummings GR, Rodning CB, Brevard SB, Gonzalez RP. Is helicopter evacuation effective in rural trauma transport? Amer Surg. 2012;78:794-797 [26].

7.5.1 Objective

The study's goal was to determine whether HEMS transport from rural settings, was associated with improved trauma survival.

7.5.2 Method

7.5.2.1 Study Design

This retrospective chart review examined air versus ground transported cases stratified by ISS and mean distance from receiving trauma center. No other adjustment was performed. The study apparently calculated straight-line transport distances (*i.e.* not distances over

roads), using an undescribed approach, from the point of patient pick-up to the receiving trauma center.

7.5.2.2 Setting

Patients were transported to a single Level I trauma center in south Alabama (USA). Crew configuration for the transported patients was not described.

7.5.2.3 Time Frame

Study patients were transported during the years 2007 and 2008.

7.5.2.4 Patients

Patients were a consecutive series of rural (as defined by U.S. Census Bureau) air and ground transports to the receiving center.

7.5.2.5 Analysis

The study analytic approach was unclear; there were no statistical methods described in either the Methods or Results. There were no confidence intervals or *p* values or test statistics reported.

7.5.3 Results

HEMS did not appear to improve survival for rural trauma patients. For the low-ISS patient group, HEMS transport distances were shorter than distances for ground transported patients. (These are the results and wording reported by the authors; no statistical testing was provided to justify the statements in the Results section.)

7.5.4 Authors' Conclusions

Helicopter transport failed to improve outcome, and HEMS transports were characterized by shorter travel distances in low-acuity patients.

7.5.5 Commentary

In its use of ISS as the sole means of acuity adjustment, this study stands in stark contrast to virtually all other analyses of transport mode and trauma outcome. The absence of reporting of any statistical testing (including any methods or analytical results) further obscures whatever meaning there may be in these data. Even within the treatment of the ISS variable, there is substantial potential for residual confounding. Previous analysis in similarly large states including much rural geography used the ISS cutoffs with which many readers will be familiar: <15, 15-30, 30-45, 45-60, >60.[32] That earlier study's finding of significant effect modification (i.e. significant interaction terms) in the ISS-HEMS outcomes association, illustrates the need for ISS categories that are narrower than used in the current study; the authors of the current study cite that previous work but apparently failed to recognize the effect modification demonstrated by the statistically significant interaction terms. Since the paper does not include the within-stratum ISS "spread" for HEMS and ground EMS, it is possible that the "ISS>30 group" may have higher ISS for HEMS as compared to ground EMS. Furthermore, there is a reason that nearly all studies in the HEMS literature include

other covariates in models assessing transport mode and outcome; ISS alone does not account for variables such as injury type and physiology, which are known to significantly influence trauma outcome even when ISS is taken into account.

The presence of residual confounding, the scant descriptive statistics, and the absent analytic statistics combine to severely restrict this study's ability to generate meaningful results. The distance calculations, while limited by the acuity-adjustment shortcomings, are reasonably interpreted by the study authors as dictating need for further assessment of cost-effectiveness in their area.

7.6 Ryb GE, Dischinger P, Cooper C, Kufera JA. Does helicopter transport improve outcomes independently of emergency medical system time? J Trauma. 2013;74:149-156 [24].

7.6.1 Objective

The study's goal was to evaluate the effect of Helicopter Emergency Medical Services (HEMS) on trauma patient mortality and the effect of pre hospital time on the association between HEMS and mortality.

7.6.2 Method

7.6.2.1 Study Design

This was a retrospective database study.

7.6.2.2 Setting

The study patients were cared for in myriad settings across the U.S.

7.6.2.3 Time Frame

Patients were drawn from the 2007 data of the National Trauma Data Bank (NTDB).

7.6.2.4 Patients

The study included all adult (>17 years) scene trauma patients transported by ground (84.7%) or air (15.3%) EMS, with complete ISS and RTS data ($n=192,422$) in the NTDB.

7.6.2.5 Analysis

The approach was mainly use of logistic regression that adjusted for variables of age, sex, ISS, RTS, injury type, hypotension, trauma center designation level, and EMS time. The variable of pre hospital time was dichotomized at the 60-minute cutoff. Multiple subgroup analyses were also performed. There was no multiple imputation or other analytic treatment of missing-variables cases. For pre hospital times data, an additional category was added (to the existing categories of <60' or >60') for "unknown." Patients without ISS or RTS simply excluded from analysis altogether.

7.6.3 Results

The overall impact of HEMS on mortality was significantly favorable. The OR for the main outcomes model was 1.78 (95% CI 1.65-1.92) and the OR for the model including pre hospital time was 1.62 (95% CI 1.50-1.76). The authors' results includes finding that "a positive effect of air transport on survival is present across all injury severity ranges." However, with regard to RTS there was a positive effect only on those cases with RTS <6 (OR 2.28, 95% 2.10-2.49); with RTS at least 6 there was a *deleterious* effect of HEMS transport on survival (OR 0.83, 95%CI 0.74-0.94).

7.6.4 Authors' Conclusions

There is an across-the-board favorable impact of HEMS transport on patients with all ranges of injury severity that appears to be unrelated to pre hospital times as assessed in this study. HEMS' positive impact is limited to patients with physiologic derangement as indicated by RTS less than 6; HEMS appears to be harmful for patients who are less severely physiologically deranged. Factors other than trauma times (e.g. crew expertise) most likely mediate the salutary effect of air medical transport on trauma outcomes.

7.6.5 Commentary

This was a study from the 2007 NTDB database, which has now provided full or partial data for at least three major studies of HEMS transport and outcomes [22,33]. Given the positive results from the previous analyses including the same 2007 data, the overall finding that HEMS improves outcomes is expected. The authors point out that their new angle is the focus on assessing pre hospital transport times. These data were not assessed in previous studies, largely because of the unreliability of the numbers and the fact that so many cases had missing pre hospital times.

As the authors themselves point out, previous attempts to look at the NTDB times data have yielded no evidence for impact of times on HEMS' positive mortality effect [22]. The current study—as pointed out by the authors in their discussion—is limited by the absence of critical data for many parameters (e.g. pre hospital RTS). EMS time was unknown for nearly half (46%) of cases. The authors' choice of dichotomizing transport times into <60 or >60 (with a third group for "unknown") is certainly a defensible approach, but nevertheless (as pointed out by the discussion after the paper in the J Trauma) it risks muddy waters in terms of time-distance relationship (i.e. 50 minutes' air transport time corresponds to a greater distance than 50 minutes' ground transport time). Furthermore, the study could be argued to suffer significantly from the absence of any attempt (e.g. multiple imputations) to deal with missing data in an NTDB dataset that was already subjected to all of the biases inherent in a convenience sample.

The authors' finding that HEMS transport was most beneficial in cases with the most physiologic derangement got a lot of attention in the post-paper discussion published in the pages following the article, but this seems hardly surprising given the widely understood fact that HEMS will help neither the trivially nor the mortally injured. As for the finding that HEMS—despite being found to be positive in impacting mortality across the entire injury severity range—is somehow worsening outcome in those patients with lesser physiologic derangement, the most likely explanation to these reviewers seems (by far) to be data-related (e.g. missing data) and confounding, rather than some heretofore unidentified

mechanism by which flight worsens outcome only in those patients with more stable vital signs.

7.7 Andruszkow H, Lefering R, Frink M, Mommsen P, Zeckey C, Rahe K, Krettek C, Hildebrand F. Does helicopter transport improve outcomes independently of emergency medical system time? Crit Care. 2013; 17:R124; doi 10.1186/cc12796 [25].

7.7.1 Objective

The study's goal was to evaluate the effect of Helicopter Emergency Medical Services (HEMS) on scene trauma patient mortality.

7.7.2 Method

7.7.2.1 Study Design

This was a retrospective database study.

7.7.2.2 Setting

The study patients were cared for in Level I and Level II hospitals in Germany. Patients were transported by physician-staffed air or ground EMS; all pre hospital care crews included physicians.

7.7.2.3 Time Frame

Patients were drawn from the 2007, 2008, and 2009 calendar years.

7.7.2.4 Patients

The study included scene-transported patients in the German Society for Trauma Surgery, who were taken by air or ground to Level I or II centers, and who had ISS of at least 9 and complete study data.

7.7.2.5 Analysis

Multivariate logistic regression was used to adjust for about a dozen variables, and assessed HEMS *versus* ground EMS outcomes using standardized mortality comparisons predicted by both TRISS (using pre hospital data only, with ISS) and RISC (Revised Injury Severity Classification; in this study RISC included initial hospital data).

7.7.3 Results

The study collected data from a cohort of 13,220 patients; ground EMS transported 8,231 and HEMS 4,989. Patients in the HEMS cohort were more seriously injured, required significantly more on-scene treatment requiring much longer on-scene times (40 vs. 30 minutes), and had greater need for ICU services with longer hospital stays. Analysis adjusted for the obvious acuity difference between the air and ground cohorts using the TRISS and RISC prognostic scores to generate fair comparison of mortality rates. HEMS

use was associated with statistically and clinically significant outcomes improvement when measured by models incorporating either TRISS or RISC; in the primary analysis the HEMS-associated mortality reduction point estimate was 25%(95%CI, 64-86%).

7.7.4 Authors' Conclusions

Despite a higher level of injury and consequential augmentation in complexity within the HEMS cohort, patients transported by air exhibited survival benefit as compared to ground EMS.

7.7.5 Commentary

This large-scale study adds to the weight of the evidence supporting HEMS use for patients with “significant” trauma. The use of the standard covariates to adjust for baseline differences in ground and air casemix was complemented by some novel study characteristics. First was the fact that both ground and air transported patients were attended by pre hospital physicians. Little information was available about possible differences between ground and air physicians, but the general point is that this “variable” in pre hospital care probably did not “vary” too much between patients in the two study cohorts. Second, the study assessed only those patients transported to Level I and Level II centers. Inclusion of patients transported to non-trauma centers has in the past been a shortcoming of some studies [34]. Third, as the authors themselves point out, the use of either of the acuity adjustment scales (TRISS or RISC) has inherent flaws, but the use of *both* ground and air patients and a standardized mortality prediction approach—with subsequent direct comparison of HEMS versus ground—minimizes the impact of TRISS/RISC flaws on the overall study results.

One of the most important issues with respect to the study, is its contribution to the literature defining what constitutes a “significant” injury. While most literature uses the lower cutoff of ISS>15, these authors chose a priori to assess patients with ISS at least 9. First, the use of this ISS cutoff means that the 21% relative reduction in TRISS-predicted mortality should *not* be extrapolated to the predicted benefit associated with HEMS use overall (i.e. for the full set of HEMS scene transports that includes patients with lower ISS). Second, and equally importantly, those modeling the utilization review and appropriateness criteria for HEMS should consider the mounting evidence that HEMS improves outcome in patients with ISS lower cutoff below the traditional number of 15. The use of lower ISS scores to define need for HEMS is increasingly defensible, given the current study data (ISS cutoff of 9) and other evidence that there are improved outcomes when HEMS is deployed for patients with ISS lower cutoff below 15 (e.g. ISS>11 in Mitchell's Canadian study [35] and ISS>12 in an Australian study[15]). In one sense, this paper's solid methodology and large-scale dataset are useful in (yet another) demonstration of HEMS scene trauma outcomes improvement in the general range of the preponderance of the extant literature. Arguably, the most important “take-home” message of this study is the strong suggestion that regional planners and triage developers should strongly consider using an ISS of at least 9 as defining potential utility for HEMS.

7.8 Giannakopoulos GF, Kolodzinskyi MN, Christaans HMT, Boer C, de Lange-de Klerk ESM, Zuidema WP, Bloemers FW, Bakker FC. Helicopter Emergency Medical Services save lives: Outcome in a cohort of 1073 poly traumatized patients. Eur J Emerg Med. 2013;20:79-85 [28].

7.8.1 Objective

The study's goal was to evaluate the effect of Helicopter Emergency Medical Services (HEMS) on scene trauma patient mortality.

7.8.2 Method

7.8.2.1 Study Design

This was a retrospective database study.

7.8.2.2 Setting

The study patients were cared for in a Level I center in Amsterdam.

7.8.2.3 Time Frame

Patients were transported between 2004 and 2010.

7.8.2.4 Patients

The study included scene-transported patients who were transported to their receiving Level 1 center in Amsterdam, who had ISS >15.

7.8.2.5 Analysis

TRISS methodology was used to assess ground EMS survival versus predicted, and also to assess HEMS-attended survival versus predicted.

7.8.3 Results

The ground EMS patients died at the TRISS-predicted rate. HEMS-attended patients died at a lower rate than TRISS-predicted; air medical response was associated with 5.4 fewer deaths per 100 cases ($p < .005$).

7.8.4 Authors' Conclusions

On-scene HEMS care has a positive effect on the survival of poly traumatized patients, saving 5.4 additional lives per 100 HEMS deployments.

7.8.5 Commentary

This paper, which studied "poly traumatized" patients (those with ISS >15), identified a significant mortality benefit associated with scene air medical response in the Netherlands. Like other Dutch studies, the study demonstrated substantial survival benefit in this a

posteriori-defined population with severe injury. The TRISS analysis found that ground EMS patients had the same survival as predicted, but that HEMS-attended patients had survival that was 5.4/100 cases higher than predicted. The authors correctly point out that since they only examined cases that were subsequently found to have ISS>15, the next steps would be research and revision of dispatch criteria to best use the HEMS resource.

8. TRAUMA–INTERFACILITY TRANSPORT [36]

8.1 Foster NA, Eifenbein DM, Kelley W, Brown CR, Foley C, Scarborough JE, Vaslef SN, Shapiro ML. Comparison of helicopter versus ground transport for the interfacility transport of isolated spinal injury. The Spine Journal. 2013 (published online in 2013 with hardcopy publication pending): doi 10.1016/j.spinee.2013.07.478 [36].

8.1.1 Objective

The study's goal was to determine if the delays associated in ground as compared to HEMS transport were associated with neurological deterioration in patients with isolated spinal injury.

8.1.2 Method

8.1.2.1 Study design

This was a retrospective trauma registry-based analysis, comparing neurological status before and after transport and also assessing (for a subgroup of 160 patients) for radiographic deterioration identified on post-transport as compared to pre-transport spine imaging. Logistic regression was utilized for multivariate adjustment.

8.1.2.2 Setting

The study was conducted at Duke University Medical Center and included patients transported to one of eight trauma centers in the state of North Carolina.

8.1.2.3 Time frame

Study patients were those transported during 2006 and 2007.

8.1.2.4 Patients

The study included 274 interfacility transported patients with isolated spinal injury (approximately half, 47% were cervical spine injury patients), transported by either HEMS (31%) or ground EMS (69%). HEMS patients were significantly younger, with nearly twice the injury acuity of ground EMS patients, and air transported patients also were more likely to be intubated.

8.1.3 Results

In a HEMS group for whom transport time was significantly faster than ground transport (80 minutes versus 112 minutes), there was no clear HEMS advantage in terms of neurological

deterioration or pre-versus post-transport radiography. One patient – in the HEMS group – had neurological deterioration due to an expanding hematoma; there were no other patients who had post-transport worsening of neurological or radiographic findings.

8.1.4 Authors' conclusions

Ground transport for interfacility spinal injury transport appears to be safe and suitable for patients who lack other compelling reasons for HEMS; prospective study is needed to validate this study's findings.

8.1.5 Commentary

The study addresses an interesting question, that has long been speculated upon: Compared to ground transport, is HEMS better (or worse) for spine injury patients? The authors identified no advantage to HEMS, but the study's results should be considered preliminary due to many limitations, most of which were outlined by the study authors. Other than the fact that it was not clear why data analysis would be focusing on 2006 and 2007 for a paper still not published in hard-copy form six years later in 2013, there were other more concrete concerns: lack of reporting of logistic regression model fit and performance, high chance of residual confounding by variables such as differential acuity, retrospective study design, and—with regard to availability of pre-and post-transport radiographs—selection bias. Furthermore, the study's title implies that only patients with isolated spine injury were assessed, but patient characteristics (e.g. HEMS mean ISS 24 as compared to ground EMS mean ISS 14, $p < .001$) seem to indicate there was often more to the story than single-system spinal trauma. Shortcomings aside, the authors make a good beginning towards a common-sense argument that patients with spine injuries that are not time-critical, may be reasonable candidates for ground transport.

9. CONCLUSION

The review of literature from 2012 and 2013 is intended as a critical appraisal and overview of the state-of-the-art in HEMS patient-centered outcomes evidence. The subjective article selection process was intended to highlight the most important literature as judged by the review authors; this was not intended to be, and should not be taken as, an attempt at comprehensive listing and evaluation of each and every HEMS outcomes-related study during 2012-2013.

Despite limitations inherent to the inability to include every study with conceivable relevance, the review provides data that are useful to inform the HEMS outcomes debate. The literature continues to develop, with more information becoming available for a variety of both trauma and non trauma cases.

While the relative paucity of "high-quality" trials (such as prospective, randomized controlled studies) is a weakness of the literature, there is undoubtedly value for many, in becoming familiar with the HEMS outcomes publications of these two years' time frame. In terms of their general consistency in indicating HEMS benefit for at least some patients, and in terms of their focusing further efforts at triage and utilization review for situations in which HEMS is most likely to improve outcome, the studies reviewed in this discussion can be said to represent important additions to the pre hospital evidence base.

As with most areas of clinical investigation, the HEMS outcomes literature would benefit from more focused, prospective, and even randomized-controlled designs where possible. Other reviews and areas for future focus could assess areas not highlighted in this review; for example the areas of finance, triage, and cost-effectiveness on a large-scale policy level warrant further attention. Readers with interest in pursuing these issues further are recommended to consult both the primary literature mentioned in this review, and resources such as the National Association of EMS Physicians website (which includes position statements dealing with issues such as appropriate HEMS use): www.naemsp.org.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

10. LIMITATION

Before conclusions can be drawn from this review, the limitations of the methodology and discussion must be considered. It is, in fact, *not* the intent of the authors, for the review's reader to draw comprehensive conclusions; the limitations inherent in this review's methodology preclude any definitive conclusions' being reached. The intent is rather to bring together and briefly address high points of what is subjectively judged by the authors to be the most important HEMS outcome-related research of the 2012-2013 timeframe. There is critical appraisal of the studies' methodology, but the review's own methodology is not one of rigidly structured collection and presentation of all relevant evidence, and the review's commentary itself is neither structured nor meant to address every strength and weakness of the collected literature. Instead, as has been the case with all of the previous reviews in this series,[1-5] the narrow intent of this review is to present for consideration and potential utility to those with connections to HEMS, a compendium of air medical transport research that has particular interest and application in the admittedly subjective opinion of one set of authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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