

ANNOTATED REVIEW

HELICOPTER EMERGENCY MEDICAL SERVICES TRANSPORT OUTCOMES LITERATURE:

ANNOTATED REVIEW OF ARTICLES PUBLISHED 2000–2003

Stephen H. Thomas, MD, MPH

ABSTRACT

Helicopter emergency medical services (HEMS) and its possible association with outcomes improvement continues to be a subject of debate. As is the case with other scientific endeavors, debate over HEMS usefulness should be framed around an evidence-based assessment of the relevant literature. In an effort to facilitate the academic pursuit of assessment of HEMS utility, in late 2000 the National Association of EMS Physicians' Air Medical Committee 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. Given the broad interest in the earlier reviews, and the increasing rate of publication of HEMS studies, the current project was executed with the intent of updating the annotated HEMS outcomes-related bibliography, covering a three-year time interval (through 2003) since the prior reviews. **Key words:** HEMS; helicopter transport; outcomes; trauma; nontrauma; scene; interfacility.

PREHOSPITAL EMERGENCY CARE 2004;8:322–333

Despite the frequency of helicopter emergency medical services (HEMS) transport, and the controversy that surrounds its cost and benefit, few comprehensive reviews encapsulate extant HEMS outcomes-related research. In 2002, two annotated bibliographies prepared by the National Association of EMS Physicians'

Air Medical Committee addressed the HEMS outcomes-related literature for trauma and nontrauma diagnoses.^{1,2} Commentary was provided for each article, but 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.

As had been planned, the Air Medical Committee was able to benefit from having prepared the first set of annotated bibliographies (e.g., in providing references supporting updating of HEMS dispatch guidelines and position statements). Somewhat less expected was the widespread interest expressed by *Prehospital Emergency Care* readers and others, from the United States and around the world, in obtaining reprints of the articles.

Even as the previous reviews are disseminated, however, it has become clear that the air medical literature is not standing still. In fact, many important studies have been published since mid-2000. The intent of this article is to continue the work of assembling outcomes-related HEMS literature, following the methods of the initial annotated bibliographies, and to provide an overview of the HEMS research published since the last set of reviews. Though covering only three years, the current review encompasses quite a few studies. It is hoped that participants in the HEMS outcomes dialog can benefit from this organized presentation of the pertinent science.

METHODS

A computerized literature search was performed. The search database was the National Library of Medicine's Medline (online *Index Medicus*), extending from 2000 through 2003. The search methods and terminology used for this review were the same as those employed by, and reported in, the previous reviews.^{1,2} For the current review, there were nearly 400 studies assessed

Received September 2, 2003, from the Department of Emergency Medicine, Massachusetts General Hospital/Harvard Medical School, Boston, Massachusetts; and Boston MedFlight, Boston, Massachusetts. Revision received December 18, 2003; accepted for publication December 20, 2003.

Address correspondence and reprint requests to: Stephen H. Thomas, MD, MPH, MGH Department of Emergency Medicine, 55 Fruit Street, Clinics Building #115, Boston, MA 02114-2696. e-mail: <thomas.stephen@mgh.harvard.edu>.

doi:10.1016/j.prehos.2003.12.028

for possible inclusion (by review of title, abstract, or full-length paper).

The papers included in the review are categorized into diagnostic areas. Within each category, papers are listed chronologically starting from the earliest publication year. The first category, *General*, assesses studies of HEMS use in transporting general nontrauma and/or mixed (i.e., trauma plus nontrauma) patient populations. The next category, *Cardiac*, addresses the use of HEMS for patients with acute coronary syndromes. A *Stroke* category reflects the increasing potential for use of air transport to facilitate rapid transfer of patients with ischemic stroke to centers capable of advanced evaluation and specialized therapy. The review concludes with trauma categories overviewing HEMS use for *Burns*, *Head Injury*, and *General Trauma*. Within categories, articles are listed chronologically.

As was the case with the previous annotated bibliographies, commentary has been provided with intent to serve as an aid to placing studies in perspective. For further background information, such as explanation of mechanisms for assessing outcomes studies, the reader is referred to the earlier annotated bibliographies.^{1,2}

REVIEW

GENERAL

• Skogvoll E, Bjelland E, Thorarinsson B. Helicopter emergency medical service in out-of-hospital cardiac arrest—a 10-year population-based study. *Acta Anaesthesiol Scand*. 2000;44:972–9.

Objective The study's aim was to evaluate HEMS involvement in out-of-hospital cardiac arrest and assess whether HEMS had an impact on mortality.

Methods

Study Design Retrospective review of operations logs and medical records.

Setting The study HEMS system covered the central part of that Norway (an area with population 364,000), using three bases. Staffing of the helicopters included anesthesiologists with "considerable experience in emergency medicine." Patients were transported to a regional referral center. Most of the HEMS group were initially attended by basic life support (BLS)-level emergency medical technicians (EMTs).

Time Frame Study patients were transported between 1988 and 1997.

Patients Subjects were 424 primary (i.e., scene) mission patients who either were in cardiac arrest at the time of HEMS activation ($n = 361$) or went into arrest after HEMS activation but before HEMS arrival at the patient's location. Patients who were rapidly resuscitated with minimal intervention (e.g., those who awoke

after "a few chest thumps" or assisted ventilations) were not included in the study.

Analysis The potential contribution of HEMS to mortality reduction was evaluated by the panel technique, with the adjudicators of HEMS following predefined standards for patient assignment. Additionally, the authors assessed HEMS response times (i.e., call received to HEMS arrival to patient) to test the hypothesis that an association between shorter HEMS response times and higher survival would be an argument in favor of the contribution of HEMS to mortality reduction.

Results Most patients (78%) suffered from primary cardiovascular disease; all but two of the 36 eventual survivors came from this group (the other two patients had gone into arrest after hypothermia and electrical injury). Of the 36 survivors, who constituted 8.5% of the eligible HEMS missions, 29 (80%) had been resuscitated before the arrival of HEMS. The other seven survivors had a return of spontaneous circulation only after HEMS arrival and intervention (in two cases, physicians had responded via ground vehicle; in the other cases, BLS was the only response prior to HEMS). For a total of 17 patients (4% of 424), HEMS intervention was judged to be a major contributing factor to survival. Nearly all (95%) of the survivors had good functional outcome. There was no evidence of improved survival associated with decreased time for HEMS response.

Authors' Conclusions Survival following HEMS involvement in out-of-hospital cardiac arrest was low, but not negligible. On a per-annum basis, HEMS use was associated with survival of one extra patient per 200,000 population in the service area. The HEMS survival benefit was time-independent, within the observed response window of 15 to 35 minutes.

Commentary This study is subject to the same limitations that always attend retrospective assignments of potential HEMS benefit, but the project was conducted with a relatively high level of scientific rigor. The Utstein style was followed for variable definitions, the inclusion criteria were set to minimize chances of "overcall" of beneficial HEMS effects, and outcomes included both neurologic status and survival (to hospital discharge and also at one year after the flight). Additionally, the authors set up well-structured a priori definitions for determining whether HEMS had had a potentially important impact on survival. The establishment of a category in which HEMS was "less important" also guarded against overestimation of HEMS impact; for example, patients who were intubated by HEMS were not necessarily considered to have benefited from air transport. One of the best things about this paper is that the authors list clinical details of all 36 survivors in a detailed table, indicating which of the patients met their a priori criteria for

defining a possible HEMS contribution to preventing mortality. Given the information in this table, the reader of the paper can make an independent judgment about the potential contribution of HEMS. Regardless of whether one agrees with the authors' definitions for determining the association of HEMS with survival, one cannot help but wish that all such "panel"-type studies reported information with the same level of detail. In fact, details such as outlining a near-certain HEMS "save" of a hypothermic cardiac arrest patient in a wilderness setting help to frame both the difficulties of measuring, and the hazards of extrapolating, true mortality benefits associated with helicopter transport.

- Lossius HM, Sorcide E, Hotvedt R, et al. Prehospital advanced life support provided by specially trained physicians: is there a benefit in terms of life years gained? *Acta Anaesthesiol Scand.* 2002;46:771-8.

Objective The study's aim was to examine the benefits of helicopter transport as compared with ground transport, and to separate putative gains attributable to advanced-level (i.e., by anesthesiologists) prehospital care from those related to use of the helicopter per se.

Methods

Study Design Retrospective review of operations logs and medical records, with modified Delphi technique for multidisciplinary review of information and attribution of life-years gained.

Setting The study HEMS system, based in Stavanger, Norway, covered the southwestern region of the country (an area with population 350,000). The helicopters (which covered farther-away calls) and identically staffed rapid-response ground vehicles (which covered closer-in calls) were crewed by board-certified anesthesiologists with experience in prehospital care. Patients were transported to the area's Rogaland Central Hospital. Relevant to the study's interpretation were the study's design of having ground response to close-by areas; the response times (i.e., to arrive at the patient) for helicopters were nearly threefold those of ground units (21 minutes vs. 8 minutes).

Time Frame Study patients were transported during an 18-month period starting in mid-1998.

Patients Subjects were 1,106 patients evaluated by the advanced-practice prehospital teams. In 447 (40%) cases, the teams transported patients by helicopter; in the remaining 659 (60%), the response was by ground vehicle. In addition to the previously mentioned difference in response times, helicopter and ground patients also differed significantly with respect to diagnostic category.

Analysis The authors prepared detailed case reports "using standard forms and neutral formulations," and these reports were reviewed by expert panelists for adjudication as to whether the advanced prehospital

capabilities resulted in a gain in life-years over what would have been achieved by non-advanced prehospital providers responding in the absence of the anesthesiologist teams. The panelists first determined whether the advanced response level resulted in a gain in life-years, and then assessed whether the life-year gains were due to the composition of the team or the speed of the vehicle. In an additional analysis, a logistic regression model was generated with the dependent variable "any gain in life-years" and independent variables that included injury acuity, diagnostic group, and air versus ground transport mode.

Results Life-years were gained in 7% of helicopter and ground missions (74 of 1,106). The benefits were limited to a few patients (13 patients accounted for 70% of life-years gained), and were largely (80%) due to the presence of the anesthesiologist; for transports involving advanced (i.e., anesthesiologist) prehospital care, there was no association between ground versus air transport mode and number of life-years gained. However, compared with ground transport, helicopter-transported patients had a significantly ($p = 0.0002$) greater chance of gaining life-years (i.e., as measured as a dichotomous outcome). Additionally, the clinically and statistically significant association between helicopter transport and likelihood of gaining any life-years (odds ratio 2.8; 95% confidence interval [CI], 1.3-6.0; $p = 0.0009$) was further emphasized in multivariate logistic regression analysis, adjusting for multiple assessors of acuity as well as diagnostic group.

Authors' Conclusions The authors' primary conclusion was that the life-year gains accrued through use of an advanced prehospital response system were primarily due to presence of advanced-level practitioners on the transport vehicles.

Commentary This is another panel-type study, using a design that the authors acknowledge as an imperfect tool, but one into which extant clinical research circumstances often force HEMS researchers. The authors' scientific rigor was admirable, but some issues were problematic. For instance, the entire calculation of life-year gains was based on artificial generation of likely outcomes from theorized "baseline" (i.e., non-advanced EMS response) care; the process of generating these baseline outcomes was both complicated and important. The authors are probably correct when they assert that the design would have introduced a bias against a health benefit attributed to advanced-level prehospital care in either ground or air vehicles (as compared with the theorized performance of more basic EMS response).

If the life-year gains assignments are accepted, then the interpretation of the results is the next step. The authors' primary goal was to demonstrate that EMS systems such as theirs benefit from the addition of advanced-level (i.e., anesthesiologist) staffing. Their

discussion makes clear that they were not out to compare air with ground transport, but rather to assess anesthesiologist-staffed advanced-response vehicles (and ground) as compared with "standard" EMS. Thus, the authors' main conclusion—that anesthesiologist-staffed EMS is often helpful—is not affected by the differing casemixes and response times for the air-transported and ground-transported patients.

There is something in this study for both sides of the HEMS debate. The overall thrust of the authors' discussion was that it was the personnel, rather than the vehicle, that improved outcome. On the other hand, there is mention of arguments about the logistic feasibility and clinical experience dilution issues surrounding advanced-level ground EMS coverage of a wide service area. Additionally, the authors point out that HEMS was sometimes the only way to get to patients. Finally, when "gain of any life-years" was analyzed as a dichotomous variable in both univariate and a priori planned multivariate models, helicopter transport was strongly associated with better outcome.

- Kurola J, Wangel M, Uusaro A, Ruokonen E. Paramedic helicopter emergency service in rural Finland—do benefits justify the cost? *Acta Anaesthesiol Scand.* 2002;46:771–8.

Objective The authors set out to investigate the benefits of HEMS, and relate them to costs of the service. As a secondary goal, the study sought to determine whether HEMS-associated benefits were related to early ALS or to rapid transport of patients to definitive care.

Methods

Study Design The study used a (two-person) panel review technique to assess whether patients had benefited from HEMS and, if so, to determine whether the benefit was related to early ALS or expedited transport.

Setting The study was conducted in Finland, at the paramedic-staffed HEMS unit servicing the eastern part of that country. The HEMS unit was simultaneously dispatched with ground units that usually lacked ALS capability.

Time Frame Patients were transported during 1999.

Patients Patients in the study were accrued from the set of 588 requests for HEMS response, but in fact only 26 cases (of all diagnostic types) involved actual helicopter transport: 233 missions were aborted because of logistics or ground-unit cancellation; an additional 57 patients died on scene; 268 patients were transported by ground or not at all; and data were missing in four cases.

Analysis Patients were retrospectively assigned to one of four groups. The first group were those who were deemed to have received "life-saving" benefit by undergoing procedures that "clearly saved the patient's life" (e.g., defibrillation, ventilation of apneic patients,

or "rapid transport which saved time for life-saving action in emergency room or operating theater"). "Beneficial effect" was said to be present for patients who "clearly benefited from helicopter service, but [in whom] benefit was not solely due to the helicopter unit" (e.g., provision of early intubation for head-injured patients, or early thrombolysis for patients with acute coronary syndromes). "No evidence for better outcome" was the category for patients in whom mortality was not improved but in whom there could have been other procedures that "made treatment easier" (e.g., analgesia or intravenous access). The final group, "no beneficial effect," included patients in whom no helpful prehospital treatment was provided or who died in the hospital.

Results Survival was affected by HEMS in three cases, and there were additional benefits in another 42 patients.

Authors' Conclusions A minority of patients benefited from HEMS, and most of the benefit was due to early ALS; the cost per beneficial mission was nearly \$30,000 (U.S.).

Commentary When a study sets out to assess the cost-benefit of a year's worth of HEMS missions and finds that fewer than one in 20 HEMS dispatches resulted in a helicopter transport, the external generalizability of the research is a bit suspect. It is true that, in Finland, the HEMS crews often accompany patients to local hospitals with ground units, but the authors themselves reported some surprise at the finding that 40% of their missions were aborted outright. Like many panel studies, this paper was characterized by a design that tried to be objective but had mixed success. For instance, one patient whose life was "saved" had received thrombolytic therapy 90 minutes earlier than would have been the case without HEMS, but another 11 who received lysis from HEMS were classified in the second-tier benefit category, and an additional five had HEMS-administered lysis with "no effect" on outcome. Overall, this study's results are difficult to extrapolate. For instance, in most countries (including the United States), HEMS-crew administration of lysis is not even a possibility, and the air-transport completion rate for most HEMS units is far higher than the 5% in this study. Therefore, although this paper is interesting and likely useful in Finland, its conclusions have limited extension to other practice settings.

CARDIAC

- Grines CL, Westerhausen DR, Grines LL, et al., and the Air PAMI study group. A randomized trial of transfer for primary angioplasty versus on-site thrombolysis in patients with high-risk myocardial infarction. *J Am Coll Cardiol.* 2002;39:1713–9.

Objective The study set out to determine if outcomes improvement was accrued via rapid transport to

a tertiary care center providing primary percutaneous coronary intervention (PCI), as compared with a control group of patients receiving thrombolytic therapy at referring hospitals.

Methods

Study Design In this prospective, randomized trial (with outcomes assessment by blinded adjudicators), on presentation to a community hospital (lacking PCI capability), patients were randomized to receive thrombolytic therapy or to undergo transport (by air or ground, whichever was "most expedient") to the receiving cardiac center for PCI. The study's design allowed the steering committee to halt the study, and such a move was executed after 39 months due to poor patient recruitment.

Setting The study encompassed a multinational cooperative effort (12 hospitals in three countries), with most patients coming from various U.S. centers; about 30% and 10% of enrollment occurred in Argentina and Finland, respectively. The study report did not include detailed information (e.g., crew configuration or vehicle type/speed) about the ground- and air-transport programs involved, nor were there details on rationale (or indeed capability) for HEMS as opposed to ground triage for the patients randomized to the PCI group.

Time Frame Study patients were transported over a 39-month period that was not specifically defined, but presumably concluded in 2001.

Patients Subjects were 138 patients who had acute myocardial infarction and who met one of six predefined criteria for high-risk classification: age older than 70 years, tachycardia, systolic blood pressure less than 100 mm Hg, Killip Class II or III, left bundle branch block, or anterior myocardial infarction. Of 71 patients randomized to the transport group, 15 (21%) were transferred by helicopter.

Analysis The authors did not set out to determine the impact of HEMS transport on mortality per se. Rather, their intent was to assess a priori defined outcomes between patients in the thrombolysis group and those in the (air and ground) transport groups. The authors performed both univariate (i.e., crude) and adjusted outcomes analysis, using a predefined set of independent and dependent variables. Outcomes assessed included death, reinfarction, stroke, recurrence of ischemia, and a combined cardiac outcomes score (called the MACE) comprising death, reinfarction, and disabling stroke.

Results The authors found that, despite the randomization of patients considered high risk, transport was safe; there were no transport-associated adverse events of consequence. Time delays for the transport group patients were extensive; the median time interval between initial hospital presentation and revascularization in the thrombolysis group (51 minutes) was less than a third of the corresponding interval (155 minutes)

in patients undergoing transfer. This outcomes improvement was clinically (bad outcome was over six times more likely in thrombolysis patients) and statistically significant (odds ratio for improvement associated with transport: 0.16; 95% CI, 0.03–0.82; $p = 0.028$) in the predefined multivariate analysis.

Authors' Conclusions In patients with high-risk acute myocardial infarction who present to hospitals lacking PCI capabilities, transport for tertiary center PCI may offer outcomes improvement as compared with traditional thrombolytic therapy at the non-PCI centers. The authors point out that the likelihood of outcomes improvement associated with transport for PCI is particularly high given that they studied high-risk patients and that preintervention times were considerably longer than expected.

Commentary First and foremost, it should be noted that, despite the name of the study (Air PAMI), most of the transport patients went by ground, not air. This, in addition to little or no information being provided on triage mechanisms, limits the conclusions that the HEMS community can draw about helicopter transport per se. However, the study's clear suggestion of benefits for early transport is a necessary (though not sufficient) step toward demonstrating a HEMS role for acute coronary syndromes. The study's illustration of the need for streamlining the transport arrangement process (the mean time for which was about half of the mean time required for actual transport) represents an obvious area in which HEMS (and ground) services can work to optimize care within a given system. The study publication was accompanied by an expert commentary, which discussed air- and ground-transport issues and contended, with much literature reference, that the question of lysis versus PCI was pretty much settled. This means that community hospitals can either begin to expand their provision of PCI, or put into place plans for expedited transfer to tertiary centers. Doubtless, some community hospitals will embrace the former solution. Just as clearly, however, not all hospitals can (or should) provide PCI, and *all* transport agencies of a given region should participate in prospective planning regarding getting patients in their service areas to the best care in a timely fashion.

STROKE

• Silliman SL, Quinn B, Huggett V, Merino J. Use of a field-to-stroke center helicopter transport program to extend thrombolytic therapy to rural residents. *Stroke*. 2003;34:729–33.

Objective The study's objective was to determine whether integration of HEMS transport for stroke into a rural EMS network resulted in improved access to stroke center thrombolytic therapy for rural patients.

Methods

Study Design The study was a prospective review of flight and hospital records.

Setting The study HEMS program and stroke center were at the Shands Hospital in Jacksonville, Florida. The HEMS program used a BK-117 with nurse/paramedic staffing. Patients were transported from rural regions (without advanced stroke care) in southeastern Georgia and northeastern Florida, using a triage mechanism entailing 9-1-1 screening and immediate HEMS dispatch.

Time Frame Study patients were transported between 1997 and 2000.

Patients The authors assessed all 111 transports of patients participating in the early-dispatch protocol. These were patients who, in calling 9-1-1, passed the screen for possible stroke. Patients were transported by ground ambulance to suitable landing zones, where they were met by HEMS that had been dispatched by 9-1-1 for the "modified scene call."

Analysis The analysis was descriptive.

Results Stroke was ultimately diagnosed (at the receiving center) in 85 patients (76%); in 47 out of 85 (42%), the diagnosis was ischemic stroke. In 17 cases, HEMS dispatch was inappropriate per a priori cutoffs for symptom duration. Thrombolytic therapy (administered intravenously in all but three cases) was administered to 18 ischemic stroke patients (38%). During the study period, stroke transports comprised 4% of the HEMS service volume, but HEMS-transported stroke patients accounted for nearly a fourth (23%) of all patients receiving stroke lysis at the receiving center.

Authors' Conclusions A helicopter-based transport system can link a rural region to a stroke center and promote access to thrombolytic therapy.

Commentary Given that this study's end point was a surrogate measure, rather than actual morbidity or mortality assessment, the inclusion of this paper in an outcomes review is subject to query. However, if one accepts the premise that early thrombolysis is of benefit, then this paper adds to the previous early investigations that begin to address whether HEMS should have a role in acute stroke care. Interestingly, two of the original counties in the study discontinued participation after their local hospitals began to provide tissue plasminogen activator (tPA) for stroke; this may be the route that some rural counties take to improve stroke care, but widespread community hospital lysis for stroke is not likely to occur any time soon. Instead, the authors' results offer another option, demonstrating that a stroke-triage protocol based on the trauma model results in the widening of a stroke center's coverage area. The authors' cogent discussion makes the point that it is a little early to attempt rigid cost-benefit analysis, but that, if the

short- and long-term benefits of stroke lysis are achieved with HEMS transport, the extra cost of air transport is worthwhile.

BURNS

• DeWing MD, Curry T, Stephenson E, Palmieri T, Greenhalgh DG. Cost-effective use of helicopters for the transportation of patients with burn injuries. *J Burn Care Rehab.* 2000;21:535-40.

Objective The study's objective was to determine whether HEMS transport improved outcome for patients with isolated burns of less than 30% total body surface area (TBSA).

Methods

Study Design The study was a retrospective chart review.

Setting This study's HEMS program and burn center were at the University of California at Davis. The HEMS program was only minimally characterized; however, by the authors' exclusion criteria, the overall transport intervention level was stated to be about the same for HEMS and ALS ground units (e.g., no patients were intubated by the flight or ambulance crews).

Time Frame Study patients were transported between 1997 and 1999.

Patients The authors excluded from analysis any burn patient "for whom helicopter transport was felt to be a more appropriate mode of transportation." Operationally, this translated into the exclusion of patients who had any of the following: possibility of inhalational injury, burn injuries over 24 hours old, one-way transport distance exceeding 200 miles, greater than 30% TBSA burned, or any associated trauma.

Analysis Outcomes in air versus ground patients were assessed using an analytic approach that matched the two groups' characteristics with respect to both TBSA and also proportion of full-thickness burns. Specific outcomes assessed were: time from injury to burn-center arrival, costs of transport, length of stay, mortality, and total ventilator days.

Results For the time period studied, 55% of HEMS burn transports (47 of 85) met the inclusion criteria. The HEMS-transported patients had a substantially shorter interval between injury and burn-center arrival (4.4 vs. 6.5 hours), but also had significantly higher transportation-associated costs. No differences were found between air- and ground-transported patients with respect to any of the other outcomes variables.

Authors' Conclusions The authors found that HEMS transport was not necessary for patients who had isolated burns, without other trauma and without potential for inhalational injury, who had less than 30% TBSA burned, and who were within 200 miles of a burn center.

Commentary It is hard to argue with the conclusion that transportation mode has little impact for patients with isolated cutaneous burns of less than 30% TBSA.

The authors correctly point out that, in such patients, the out-of-hospital requirements of analgesia and fluid administration can be met by ground ALS services. Irrespective of the logistic issues unmentioned by the authors (e.g., a local EMS region being left with less—or no—ALS coverage during its truck's 300-mile round trip for a burn transport), the primary problem with this study is that, by focusing on less-severe patients, it may be asking the right question about the wrong group. In multiple places in their paper, the authors use terms such as "more appropriate" to characterize air-transport use for the approximately 50% of their center's HEMS-transferred burn patients who failed to meet their study's stringent inclusion criteria. The study's exclusion criterion of "patients with any chance of inhalation injuries," for example, contributed to the constitution of a study population characterized by a relatively good outcome, regardless of transport mode. The authors' contribution in determining that there were no unexpected HEMS-associated outcomes benefits in this patient population is not to be minimized; however, one could arguably contend that the study question should have been whether HEMS transport is, in fact, "more appropriate" for any burn patients. A HEMS advocate would probably tend to be reassured by the authors' statements, which tend to assume a benefit for such "serious" burn patients, but, in fact, the data supporting such a contention are hard to find.

- Slater H, O'Mara MS, Goldfarb IW. Helicopter transportation of burn patients. *Burns*. 2002;28:70–2.

Objective The study's objectives were to characterize HEMS- versus ground-transported burn patients, to determine whether overtriage or undertriage was occurring, and to assess reasons for inappropriate use of the helicopter resource.

Methods

Study Design This retrospective chart review study included discussion with referring ground-EMS service directors to ascertain the reasons for triage of burn patients to the HEMS modality.

Setting The study HEMS programs, which appeared to be the two programs operating in Pittsburgh, Pennsylvania, were neither named nor characterized. Patients were those transported to Western Pennsylvania Hospital.

Time Frame Study patients were transported between 1997 and 1999.

Patients The authors assessed all burn transports to the study center that occurred during the study period; there were 437 such patients, with 98 transported by air.

Analysis Characteristics of air versus ground patients were assessed using univariate analysis.

Results Compared with ground-transported patients, HEMS-transported burn patients were far

more likely to have inhalational injury (28% vs. 3%), and had significantly greater TBSA (21% vs. 8%). Some air-transported patients had relatively minor injuries, and some ground-transported patients had severe injuries; in each of these groups, there were patients who seemingly should have been transferred using the alternative modality.

Authors' Conclusions The authors concluded that HEMS benefits some burn patients, but that the resource is overused.

Commentary This paper arguably is not a candidate for inclusion in this review, because there is no direct air versus ground outcome comparison. However, the study appeared in a journal not usually perused by the emergency medicine and EMS communities, and it addresses some interesting and relatively unstudied factors (e.g., nonmedical rationale for HEMS triage). The authors directly imply an outcomes benefit associated with HEMS transport of severe burns, but they provide no outcomes data to support these contentions. In a balanced discussion, the authors argue that helicopters are often overused, but sometimes underused. The primary utility of the paper is that it studied—and stated outright—what many trauma-systems experts have long known: triage decisions are very often governed by nonmedical considerations, such as payer status and reluctance of ground EMS agencies to leave their service areas uncovered.

HEAD INJURY

- Dardis R, Roberts G, Phillips J. A cost-benefit evaluation of helicopter transports to the Beaumont neurosurgical unit. *Irish Med J*. 2000;93:50–1.

Objective The study objective was to assess helicopter-transported head injury patients, and determine what the transport times were and whether patients appeared to benefit from rapid air transport.

Methods

Study Design The study assessed prospectively collected data that examined transport times as well as patient clinical parameters and outcomes.

Setting The study was conducted in Ireland, at the Beaumont Hospital in Dublin (which receives patients from much of the country). Patients were transferred by either an Alouette or a Dauphin (all of the results were categorized by aircraft type). "Virtually all intubated patients" were transported by a team consisting of an anesthesiologist and a nurse; the study did not make clear how other transports were staffed.

Time Frame Study patients were consecutive transports occurring over a 36-month period between 1994 and 1996.

Patients Subjects were 55 patients (most trauma, but also with nontrauma diagnoses) transported to the neurosurgical unit by helicopter. As an indicator of

patient acuity, 25% of the study patients required neurosurgical operative intervention within two hours of arrival at Beaumont Hospital.

Analysis Analysis was descriptive, with travel times recorded for helicopter and ground vehicles. Transport times were broken down into all pertinent transport legs for air transports, which often involved (lengthy) trips between hospitals and airport helipads.

Results The authors' review found that "the clinical decision for helicopter transfer was appropriate for the majority of patients." The travel times, including the intratransport times (i.e., actual time in the transport vehicle), were found to favor helicopter transport, but extra (ground) transport legs between helipads and referring and/or receiving hospitals incurred significant delays. Overall, the use of the helicopter appeared to save about one to three hours compared with ground-ambulance transport.

Authors' Conclusions The extra cost of using helicopters for transport can probably be justified to achieve a shorter time period in the "unstable transfer environment."

Commentary Despite the paper's title, this was not a cost-benefit analysis in any formal sense, and the methodology was not particularly rigorous (e.g., no comparison with ground-transported patients or with "expected" outcome). The authors' conclusions may seem like common sense to anyone with expertise in the prehospital arena; but, on the other hand, the relatively loose methodology invites criticism (by those who do not think HEMS useful) that studies of this design do not make a compelling argument. One potentially important point that the authors make very well is that using a helicopter cannot achieve its maximum benefit if extra ground-transport legs between helipads and hospitals are too long; this is definitely a lesson with which HEMS providers in the United States (and elsewhere) would agree.

- Macnab AJ, Wensley DF, Sun C. Cost-benefit of trained transport teams: estimates for head-injured children. *Prehosp Emerg Care*. 2001;5:1-5.

Objective Beginning with the well-proven premise that adverse events during transport (e.g., hypotension or hypoxemia) can adversely affect outcomes in head-injured patients, the authors set out to assess whether provision of air-ambulance paramedics with special pediatric-transport training would decrease the incidence with which preventable insults occurred.

Methods

Study Design The study was a retrospective review of transport and hospital records.

Setting The study was conducted in British Columbia, Canada. The study period was during a time when the provincial air-ambulance service was in transition from a system in which prehospital (nonphysician)

providers did not have specialized pediatric and/or transport training, to a system in which such training became available.

Time Frame Study patients were transported over a 12-month period, which was not specifically named, though it seems that the study patients were a subset of a study cohort initially collected before 1991.

Patients Subjects were all children ($n = 43$) at least 1 year of age, who were head-injured and who were transported to tertiary care during the study period.

Analysis The main analysis was performed with cost-benefit techniques. Assessment of incidence of adverse events was performed (comparing transports in which crews did vs. did not have the additional pediatric-transport training), and the authors calculated additional costs of care resulting from the secondary adverse events during transport.

Results There were significantly fewer adverse events in the patients attended by prehospital personnel with extra training (55% vs. 12%, $p < 0.05$). Though the actual cost numbers are not easily translated (they are reported in 1988 Canadian dollars), the authors found that the additional costs of providing pediatric transport training to the air-ambulance providers were more than offset by the benefits reaped in terms of reducing intratransport adverse events. For the cost-benefit analysis to support such training overall, the authors stated that a service needs to transport only one head-injured child per week.

Authors' Conclusions The authors, determining that improved crew training resulted in fewer adverse events and thus substantial reductions in acute and rehabilitative care, concluded that providing extra pediatric-transport training to air-ambulance providers is cost-beneficial. The authors also pointed out that there was little reason to believe that the improved intratransport care was limited to head-injured patients, merely that the head-injured population was easier to study.

Commentary Although the study had no ground-transport control group, and the low study numbers precluded robust results (there were only 18 adverse events in all), the authors' attempts to perform a financial assessment of the air-ambulance service are to be applauded. Whether similar outcomes could be achieved by a similarly trained ground-ambulance group remains to be seen, but of course the costs of training a much larger group of ground providers would be higher, and the critical "continuing education" of performing frequent transports would be more difficult to meet.

- Di Bartolomeo S, Sanson G, Nardi G, Scian F, Michelutto V, Lattuada L. Effects of 2 patterns of prehospital care on the outcome of patients with severe head injury. *Arch Surg*. 2001;136:1293-300.

Objective Postulating that HEMS was particularly likely to be of benefit in patients with critical head injuries, the authors set out to assess severely head-injured patients to compare outcomes between ground and HEMS systems of care.

Methods

Study Design The study assessed prospectively collected data that were part of the region's participation in accruing data for a trauma outcomes database. Outcomes assessed were mortality and Glasgow Outcome Score.

Setting The study was conducted in northeastern Italy, in an area with ground-EMS response characterized by one nurse (accompanied by one or two BLS-trained drivers), and HEMS response staffed by two nurses and an anesthesiologist.

Time Frame Study patients were transported over a 12-month period between 1998 and 1999.

Patients Subjects were eligible if the Injury Severity Score (ISS) was at least 16 and if the head Abbreviated Injury Score (AIS) was at least 4. There were 92 patients transferred by HEMS, and 92 patients transferred by ground.

Analysis Analysis was both univariate (with and without stratification by a number of variables) and multivariate (using logistic regression). The authors performed some a priori defined subgroup analysis (e.g., hypotensive patients, patients requiring urgent neurosurgical intervention) in an attempt to maximize the chances of finding any HEMS-associated outcomes benefit.

Results The main finding was that there was no overall mortality or Glasgow Outcome Scale score differences between the air and ground groups. Furthermore, for most of the subgroup analyses, there were no differences in outcomes as measured by either parameter. Compared with ground patients, HEMS patients were much more likely to receive most ALS interventions (including ventilation and intravenous fluid replacement), and reached definitive care hospitals much more quickly.

Authors' Conclusions Although the study's bias should have maximized chances of identifying HEMS benefits, the benefit was found for only one group (i.e., those needing urgent neurosurgery).

Commentary This well-designed, cogently presented study reported some signs of improved outcome for HEMS patients (e.g., the Glasgow Outcome Scale tended to be higher in all analyses for patients of HEMS), but most of the results were negative, and outcome improvement reached statistical significance only in patients requiring neurosurgical intervention. As is the case with many other studies, this project's generalizability may be affected by regional practices in prehospital data assessment and recording (e.g., it seems unusual that over half of the ground-EMS

group's patients with recorded GCS of 3 survived). The authors' discussion of possible confounders and explanations for their findings are thorough, thoughtful, and unbiased. They point out that, although many of the study's biases should have favored HEMS, the ground and air patients may well have differed in composition. For example, the proportions of secondary missions for HEMS and ground patients were 4% and 45%, respectively. In another a priori planned subgroup analysis (for hypotensive patients), the authors pointed out that, as a result of differences in age and ISS (both higher for HEMS patients), the survival predicted by Trauma Injury Severity Score (TRISS) for the ground group was nearly fourfold that for HEMS patients, whereas actual survival was only moderately higher (65% vs. 48%). This study's discussion is notably comprehensive, and the authors' conclusion that HEMS resulted in improved outcome for only a limited number of head-injured patients appears sound. Notably, some of the same authors found that there *was* an outcome benefit—an approximately threefold reduction in mortality—associated with the higher level of care in an earlier study of blunt trauma patients in the same region.²

GENERAL TRAUMA

- Wills VL, Eno L, Walker C, Gani JS. Use of an ambulance-based helicopter retrieval service. *Aust N Z J Surg.* 2000;70:506–10.

Objective The study's objective was to use a panel-review technique to assess a year of HEMS trauma-scene transports to determine whether benefit was accrued by use of the helicopter.

Methods

Study Design In this retrospective trauma database review, a panel assigned the benefit from air transport.

Setting The study was conducted out of the John Hunter Hospital, an Australian trauma center that has a helicopter service staffed with either paramedics (for primary missions) or a physician/nurse crew (for secondary missions).

Time Frame Study patients were those who arrived at the study hospital in 1996.

Patients Study patients were all ($n = 179$) trauma-scene transports to the study center, arriving via the John Hunter Hospital's helicopter service (three patients flown by another service were excluded).

Analysis All cases in which the primary investigator felt there may have been benefit were reviewed by an expert panel, with the Delphi model then used to assign (unanimously) a category of "no benefit," "benefit," or "harm" to classify the effects of helicopter transport. Benefit could be assigned based on geographic (i.e., logistic) considerations, medical interventions, or both.

Results The authors report that some benefit was accrued for 17.3% of patients, no benefit was present in 81.0%, and potential harm was done by helicopter crews in 1.7%. Likelihood of benefit from air transport was significantly higher for patients transported more than 35 km.

Authors' Conclusions The study found HEMS transport beneficial in many cases, but many transports occurred for relatively minor injuries. In the absence of specific logistic considerations, helicopter transport for patients who are within 35 km of the receiving trauma center is very unlikely to be beneficial.

Commentary This study shares the strengths and weaknesses of other panel studies. Perhaps notably, its results are not inconsistent with the overall estimates of benefit given in similar papers, but the vagaries inherent to even the most stringent application of the Delphi technique represent a study limitation that is hard to overcome. The authors' conclusion that short-range helicopter transport is rarely beneficial is reasonable, and seems well-supported by their data.

- Oppe S, De Charro FT. The effect of medical care by a helicopter trauma team on the probability of survival and the quality of life of hospitalised victims. *Accid Anal Prev.* 2001;33:129–38.

Objective The study's objective was to perform a cost-effectiveness analysis, assessing both survival and quality of life after HEMS use in the Rotterdam region of the Netherlands.

Methods

Study Design The study was an apparently prospective assessment of medical-record information as well as a collection of interview data for quality-of-life assessments after hospital discharge.

Setting The study, conducted in the Rotterdam area, assessed the use of a helicopter trauma team comprising a physician and a nurse. The air medical crew stabilized the patient at the scene but usually did not accompany the patient to the trauma center; nearly all patients were treated by the air medical crew, and subsequently were transported to appropriate facilities by ground (sometimes with the air medical crew in attendance; sometimes not).

Time Frame Study patients were those who suffered polytrauma between May 1995 and December 1996.

Patients Study patients were the injured patients during the study period, in the Rotterdam region, who either did ($n = 210$) or did not ($n = 307$) have helicopter response.

Analysis The main results reported in this paper were those addressing probability of survival. The other results (quality of life) were reported in brief, but the authors state that these results will be discussed in more detail in a later paper. The authors used the Revised Trauma Score (RTS) and ISS to adjust for

injury severity, and used a logistic regression model to assess the impact of HEMS involvement on mortality. In fact, the authors' treatment of the variables in the study was complex, and the reader is referred to the original paper for proper details. Postdischarge information was obtained by interview at nine and 15 months after the injury (for quality-of-life end points).

Results The involvement of the HEMS unit resulted in a statistically significant reduction in mortality, with varying results given depending on the various configurations of the authors' model. The data showed that up to a 17% mortality reduction was achieved by HEMS use, but the most conservative estimate from the statistical manipulations (about 7%) was used in the quality-of-life and cost assessments. The overall quality-of-life results were similar for patients who did and did not have HEMS attendance.

Authors' Conclusions The HEMS transport reduced mortality, specifically by improving survival in road-accident victims. Additionally, the preliminary cost-benefit analysis results allowed a conclusion that the benefits of HEMS use came at a cost "within a range that would be seen as acceptable in many other health care services."

Commentary The main caveat of this paper is that it may not be externally generalizable to other countries where a physician does not fly, and (more importantly) where the patients are not stabilized by HEMS and then transported by ground. Otherwise, this well-written study provides relatively detailed analysis of quality of life and HEMS transports, and seems to meet the goal of demonstrating that air response benefits those in the midrange of injury acuity. The study had an important impact, because it "contributed to the decision taken by the Minister of Health" to establish additional HEMS-response teams. If the authors continue to perform such detailed and methodologically rigorous analyses, the future will probably see more useful data assessing performance of their interesting system.

- Shatney CH, Homan SJ, Sherck JP, Ho CC. The utility of helicopter transport of trauma patients from the injury scene in an urban trauma system. *J Trauma.* 2002;53:817–22.

Objective The study's objective was to determine, for a large group of trauma patients transported directly from trauma scenes, whether overtriage was occurring.

Methods

Study Design This retrospective analysis used medical records information.

Setting The study was conducted out of the Santa Clara Valley (California) Medical Center, which is one of three level 1 centers serving nearly 2 million inhabitants in a region that lacks formal policy dictating triage to helicopter transport. The trauma center is served

by a helicopter service which is activated by prehospital providers (usually ALS) at the scene.

Time Frame Study patients were those who arrived at the study hospital between 1990 and 2001.

Patients Study patients were 947 trauma victims (nearly all with blunt trauma).

Analysis The authors examined their database of trauma patients, and assessed the transport times by air as compared with what would have been possible by ground (as determined by a panel of physicians and prehospital personnel).

Results In 55% of cases, helicopter transport was judged to be "clearly faster" than would have been possible by ground vehicle; in an additional 15% (entrapped patients), it was determined that the helicopter was "probably faster." When the group of patients potentially benefiting from air transport was defined as those with faster transport times, combined with either a need for early operation or hospitalization with ISS at least 9, the authors determined that air transport was beneficial for a maximum of 22.8% of patients.

Authors' Conclusions As HEMS transport was used excessively in the study's EMS system, criteria should be developed for triaging injured patients to air versus ground vehicle.

Commentary This study underlines the importance of cooperation between air and ground EMS agencies and their medical directors, with respect to generating policies guiding appropriate dispatch of air medical resources to trauma scenes. Agreed-upon triage criteria, imperfect though they may be, should be in place in every system. Even those who believe that helicopters may have an impact on outcome tend to believe that *in favorable traffic situations* there is little reason to deploy them in the midst of an urban area. Despite the common sense appeal of the authors' conclusions, the study is substantially limited by retrospective assignment—over a time period stretching back 11 years—of ground-transport times by a four-person panel with unclear qualifications for this task (two surgeons, one nurse, and one retired paramedic).

- Thomas SH, Harrison TH, Buras WR, Ahmed W, Cheema F, Wedel SK. Helicopter transport and blunt trauma mortality: a multicenter trial. *J Trauma*. 2002;52:136–45.

Objective The study's objective was to use a multivariate logistic regression technique to assess whether helicopter transport (from either scenes or referring hospitals) of blunt trauma patients was associated with improved survival.

Methods

Study Design In this retrospective trauma registry study, participating hospitals' trauma registries were combined into a single database.

Setting The study was conducted in Boston, Massachusetts, by Boston MedFlight, which performs trauma transports into multiple receiving trauma centers. Boston MedFlight staffing is nurse/paramedic.

Time Frame Study patients were those who arrived at the five study trauma centers during the four-year period of 1995 to 1998.

Patients Study patients ($n = 16,999$) were all trauma-scene and interfacility transports to the study centers, arriving via either ground or air ambulance.

Analysis In multivariate modeling, ISS was used as the primary acuity stratification tool. The model also incorporated other covariates (e.g., ALS vs. BLS care for the ground-transported patients).

Results The analysis found HEMS use to be associated with a significant benefit (24% mortality reduction).

Authors' Conclusions In the population studied, HEMS transport was beneficial for blunt trauma.

Commentary This study was notable for its size and its incorporation of ALS/BLS level of care into the multivariate model. As one of the largest non-TRISS studies in the literature, the paper adds weight to the TRISS literature in making the case for helicopter transport and some mortality improvement. Like other retrospective studies, the paper suffers from limitations such as lack of morbidity assessment and inability to offer other potential explanations for survival improvement.

- Chappell VL, Mileski WJ, Wolf SE, Gore DC. Impact of discontinuing a hospital-based air ambulance service on trauma patient outcomes. *J Trauma*. 2002;52:486–91.

Objective The study's objective was to assess retrospectively whether discontinuation of a HEMS program based at a trauma center had any impact on trauma mortality.

Methods

Study Design Retrospective trauma registry review at the study hospital.

Setting The study was conducted at the University of Texas Medical Branch in Galveston.

Time Frame Patients included in the study were those who arrived at the study hospital during the three-year period from 1996 to 1999.

Patients Study patients were trauma-scene transports to the Galveston trauma center.

Analysis Injury severity and outcomes data were assessed for the year immediately preceding, and for a two-year period immediately following, HEMS discontinuation. The data included transport times for both ground and air ambulance services, overall mortality, and covariates such as ISS (assessed as either ≤ 15 or higher), age, GCS, and scene blood pressure.

Results The number of trauma patient admissions to the study center decreased by 12%, and there was a 17% decrease in admissions of severely injured patients.

Overall, transport time decreased. There was no change in trauma mortality at the receiving center.

Authors' Conclusions Discontinuation of the HEMS transport service was not associated with change in mortality.

Commentary Although the results could be explained by lack of HEMS benefit, they are much more likely due to the fact that the study suffered fatally from selection bias. Because the number of patients transported by ground increased only slightly, and the overall transport times actually decreased, the commonsense conclusion is simply that a lot of seriously injured patients from relatively longer distances away from the study center were cared for—and possibly died—elsewhere. The Texas investigators were unable to assess the true variable of interest: post-HEMS-era mortality in the entire population of trauma patients who earlier would have been transported by HEMS. Because of inability to precisely track outcomes in patients who went to other centers, and because of other methodologic issues (e.g., lack of multivariate analysis or ISS stratification into more than dichotomous variables), the predominant value of the Texas study is that it laid important groundwork for an interesting study design.

- Mann NC, Pinkney KA, Price DD, et al. Injury mortality following the loss of air medical support for rural interhospital transport. *Acad Emerg Med.* 2002;9:694–8.

Objective The study's objective was to retrospectively assess whether discontinuation of a HEMS program based at a trauma center had any impact on trauma mortality for patients undergoing interfacility transfer.

Methods

Study Design Retrospective medical records were reviewed at the referring hospitals and trauma centers.

Setting The study was conducted in Oregon, and focused on patients injured in two adjacent regions. In one region, HEMS service became unavailable (after an aircraft crash and nonreinstatement of HEMS service); the four non-trauma center hospitals in this region were used as the "test" group. Test group regional outcomes were compared with outcomes of patients evaluated at four similar-sized hospitals in an adjacent region that maintained HEMS availability throughout the study period.

Time Frame Study patients were those who arrived at the study hospitals during a three-year period before, and a three-year period after, discontinuation of HEMS availability in the test region.

Patients Study patients were interfacility trauma transports. Data were collected for severely injured

patients initially presenting at rural hospitals in the test or comparison regions, and who were subsequently transferred to one tertiary trauma center in each region. **Analysis** Thirty-day mortality following discharge from the receiving tertiary facility served as the primary outcome measure. Primary analyses compared injury and transport characteristics in test and comparison regions for the two time periods. Multivariate logistic modeling was used to measure variance in mortality associated with discontinuation of rotor-wing service in the test region, controlling for potential covariates.

Results Controlling for covariates, patients in the test region transferred for definitive care were four times more likely to die after discontinuation of HEMS availability than were patients transferred while HEMS was still active. No difference was noted in the region with continued air service over the same time period. There was no difference in the death rate among patients not receiving an interfacility transfer in either the control or test region.

Authors' Conclusions Discontinuation of the HEMS transport service was associated with increased mortality in the area that lost HEMS services.

Commentary With their well-designed analysis and cogent discussion, these authors covered all of the bases in their "natural experiment" study assessing the impact of losing HEMS availability on regional trauma outcomes. The barriers to execution of this type of research design were handled quite effectively, and the authors' results and discussion make a strong case for HEMS-associated mortality improvement. After HEMS capability was lost, the region without HEMS access experienced a fourfold increase in trauma mortality whereas mortality remained unchanged in the region with continued HEMS service. The authors used elegant multivariate techniques to adjust for potential confounders, and, importantly, their findings accounted for all of the injured patients (i.e., including the ones who were not transported from the regional hospitals). The paper makes a strong case for some systemwide benefit to helicopter transport.

References

1. Thomas SH, Cheema F, Cumming M, Wedel SK, Thomson D. Nontrauma helicopter emergency medical services transport: annotated review of selected outcomes-related literature. *Prehosp Emerg Care.* 2002;6:242–55.
2. Thomas SH, Cheema F, Wedel SK, Thomson D. Helicopter emergency medical services trauma transport: annotated review of selected outcomes-related literature. *Prehosp Emerg Care.* 2002;6:359–71.