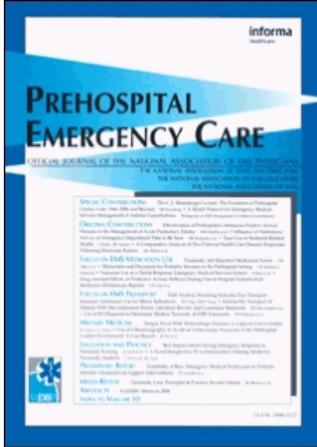


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### NONTRAUMA HELICOPTER EMERGENCY MEDICAL SERVICES TRANSPORT: ANNOTATED REVIEW OF SELECTED OUTCOMES-RELATED LITERATURE

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# ANNOTATED REVIEW

## NONTRAUMA HELICOPTER EMERGENCY MEDICAL SERVICES TRANSPORT: ANNOTATED REVIEW OF SELECTED OUTCOMES-RELATED LITERATURE

Stephen H. Thomas, MD, MPH, Farah Cheema, MD,  
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### ABSTRACT

While helicopter emergency medical services (HEMS) has its roots in military transport of wounded soldiers, rotor-wing transport is also used for a wide variety of nontrauma indications. Despite this common use of HEMS for noninjured patients, a Medline search found little systematic review of the literature pertinent to HEMS use for nontrauma. With HEMS utilization subject to appropriately increased scrutiny, those seeking to research HEMS utility in noninjured patients could benefit from existence of a collection of the topical literature. This paper aims to provide such a review, in the form of an annotated bibliography of *Index Medicus* journal studies assessing potential medical risks and benefits of HEMS transport for noninjured patients. The paper's goal is to provide a useful resource for those interested in pursuing more focused review of various sectors of the nontrauma HEMS literature. As such, the main objective of the article summaries is to provide a brief outline of study design and results; there is also limited editorial comment included after each summary. **Key words:** HEMS; helicopter transport; outcomes; nontrauma.

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After use of helicopters played an important role in the military trauma care systems of the Korean and Vietnam Wars, U.S. civilian helicopter emergency medical services (HEMS) was born in the 1970s. Given the trauma-related nature of helicopter transport in its military roots, early programs understandably focused on evacuation of injured patients to trauma centers. However, many programs transported medically ill noninjured patients, and the use of HEMS in the setting of cardiac and other nontrauma diagnoses quickly became commonplace.

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Despite the frequency of nontrauma HEMS transports, a literature search failed to identify reviews summarizing extant papers addressing medical risks and benefits associated with nontrauma HEMS transport. Therefore, it was decided to prepare an annotated bibliography on the subject, with the primary goal of providing bibliographic support for those interested in further research in this area. An additional goal of providing commentary on the summarized literature was of secondary importance. This commentary, inherently subjective, is included primarily to aid in placing the articles in perspective and is not intended to provide detailed judgments about reviewed papers.

### METHODS

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

Utilization of the search term *helicopter* returned 834 citations. The terms *rotorcraft* and *rotorwing* returned nine citations, some of which were not included in the *helicopter* search. Next, the following MeSH headings were utilized: *aircraft*, *transportation of patients*, *air ambulances*, *aviation*, *emergency medical services*, and *aerospace medicine*. Content of all papers was reviewed by title and/or abstract review. The criterion for a paper's inclusion in

this review was a requirement for the paper to address potential medical risks (e.g., pacemaker dysfunction) or benefits (e.g., outcome improvement) associated with HEMS transport of nontrauma patients. "Outcome" was defined in relatively liberal fashion. While studies comparing endpoint occurrences between HEMS and other populations were included, also included were studies addressing whether certain endpoints (e.g., equipment malfunction, thrombolysis complications) appeared to occur with increased frequency in the helicopter transport environment. It is acknowledged that some subjectivity is inherent to such a process of inclusion decision making, and therefore the authors do not claim the current bibliography comprehensive.

The papers included in the review are categorized into diagnostic categories. Within each category, papers are listed chronologically and an abstract summary of pertinent portions of the paper (not the paper's original abstract) is provided. The first category, *General*, encompasses studies of undifferentiated patient populations. These papers, some of which include trauma as well as nontrauma patients, are in our opinion very difficult to interpret due to problems (e.g., acuity stratification) inherent to the analysis of patients with myriad diagnoses. Inclusion of these papers in this review underlines the principle that perceived article quality was not a factor in selecting papers for this bibliography. The other diagnostic categories are relatively straightforward. *Cardiac* papers discuss medical risks and benefits associated with helicopter transport of patients with acute myocardial syndromes. *Neonatal* papers address transport of the newborn to specialized centers. *Neurologic* papers discuss the HEMS role in the emerging field of acute stroke therapy. *Obstetric* papers focus on advisability of transport of gravid females in the ergonomically constrained setting of a helicopter. The *Vascular* category consists of a paper describing a center's experience with HEMS transport of abdominal aortic aneurysms.

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

## REVIEW

### GENERAL

- Brismar B, Alverdy A, Johnsson O, Ohrvall U. The ambulance helicopter is a prerequisite for centralised emergency care. *Acta Chir Scand Suppl.* 1986;530:89-93.

**Objective** The study's objective was to describe and evaluate the experience of the institution of HEMS in Stockholm.

#### Methods

**Study Design** The study was a retrospective review of flight and hospital records with panel review of flights for determination of health benefit.

**Setting** The study helicopter was operated by the police and was staffed by a physician/medic crew. The service performed transports in the County of Stockholm, which includes both a densely populated city and an extensive archipelago. Patients were transported to three large general hospitals.

**Time Frame** Study patients were transported during the summer months of 1978–1983 (a total of 56 weeks).

**Patients** The HEMS group were all of the patients for whom HEMS was requested. The diagnostic breakdown was 57% illness and 43% injuries.

**Analysis** Statistical analysis was primarily descriptive.

**Results** Therapeutic intervention by HEMS doctors at the scene was considered to have been of vital importance in 22% of the cases, desirable in 28%, and unnecessary in 50%; interventions were judged to be lifesaving in 18 cases (2%). In most instances in which physician presence was judged to be unnecessary, the helicopter was used to provide the "most gentle" transport alternative for patients in island locales without bridges to the mainland.

**Authors' Conclusions** Use of physician-manned HEMS service is an important part of advanced prehospital care in the Stockholm area, resulting in health benefits. The number of unnecessary missions could be reduced with improved training of dispatchers.

**Commentary** The authors' primary conclusion is best conveyed by the title given to the paper. In addition to its relevance as a panel analysis concluding HEMS was associated with outcomes improvement, the study outlines many logistics details of instituting a HEMS service in an area with no pre-existing helicopter coverage. Some of these details are similar to the situation in the United States and many are not; the paper must be read for a full understanding of the way the HEMS program was instituted and run.

- Kee SS, Ramage CM, Mendel P, Bristow AS. Interhospital transfers by helicopter: the first 50 patients of the Careflight project. *J R Soc Med.* 1992;85:29-31.

**Objective** The study's objective was to determine whether institution of a HEMS service in the United Kingdom (UK) was associated with mortality benefit for patients undergoing interfacility transfer.

#### Methods

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

**Setting** The study HEMS program, Careflight, was staffed by an anesthesiologist/medic crew and performed transports from hospitals throughout the UK. Patients were transported a mean distance of 118 miles, to St. Bartholomew's Hospital in London.

**Time Frame** Study patients were apparently transported during 1989, but this is not specifically delineated.

**Patients** The HEMS group were the first 50 patients, excluding neonates, transported by the HEMS service. The ground comparison groups were historical groups of similar acuity reported in the previous British literature. Acuity was assessed with a sickness score.

**Analysis** Statistical analysis was primarily descriptive. There was no formal analysis of outcomes between the HEMS group and the historical ground-transported controls.

**Results** There were no deaths or health deterioration during transport. Of the 50 HEMS transports, 14 (28%) were judged to not have been achievable by ground transport. There was no correlation between transport distance and outcome. In patients with sickness scores of over 18, who would have been expected to die based on historical ground transport data, survival was 50%.

**Authors' Conclusions** HEMS transport was practical and safe for patients, and may be preferable to ground transport for distances over 25 miles. HEMS existence allowed transport of some patients to tertiary care, who otherwise would have had to remain at outlying hospitals.

**Commentary** With 84% of these interfacility transports preplanned, the data may have limited relevance to many U.S. emergency department (ED)-to-ED interhospital transfers of initially stabilized cardiac or trauma patients. The study is also somewhat limited by the methodology by which HEMS mortality benefit was assessed. More detailed delineation of the acuity measures in the historical ground transport literature, as compared with those in the current study, would have added to the paper's ability to assess outcome benefit associated with HEMS.

- Lindbeck GH, Groopman DS, Powers RD. Aeromedical evacuation of rural victims of nontraumatic cardiac arrest. *Ann Emerg Med.* 1993;22:1258-62.

**Objective** The study's objective was to determine whether deployment of HEMS contributed to improved survival in victims of rural cardiac arrest.

#### Methods

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

**Setting** The study HEMS program, Pegasus, was staffed by a nurse/paramedic crew and performed transports in rural Virginia, to the University of Virginia Health Sciences Center.

**Time Frame** Study patients were transported between January 1, 1986, and December 31, 1989.

**Patients** The HEMS group were all adults (over 15 years of age) in nontraumatic cardiac arrest at the time of request for HEMS scene transport.

**Analysis** Statistical analysis was primarily descriptive.

**Results** There were 84 patients who met inclusion criteria for the study. Resuscitative efforts were terminated in the field (no HEMS transport occurred) in 55 (65.4%). Of the other 29 patients, ten (11.9% of 84) survived to hospital admission and only one patient survived to hospital discharge. The single patient who survived to hospital discharge had been successfully resuscitated by ground EMS personnel prior to HEMS arrival and transport.

**Authors' Conclusions** Deployment of HEMS had a negligible effect on patient survival from nontraumatic cardiac arrest in a rural setting.

**Commentary** The authors point out that there are theoretical logistic advantages (e.g., provision of improved availability of advanced life support (ALS) in rural settings) to HEMS utilization in the patient population studied. However, their data represent a strong argument against benefit from HEMS utilization in patients in arrest at the time of HEMS activation.

- Hotvedt R, Kristianson IS, Forde OH, et al. Which groups of patients benefit from helicopter evacuation? *Lancet* 1996;347:1362-6.

**Objective** The study's objective was to evaluate patients transported by helicopter, and to determine using review of records whether patients benefitted from air (as opposed to ground) transport mode.

#### Methods

**Study Design** The study was a retrospective review that used a modified Delphi technique to reach consensus on life-years gained by helicopter (as opposed to ground) transport. Flights were initially reviewed by a three-person panel of anesthesiologists to determine whether there was any chance of benefit from helicopter transport. Flights passing this criterion were referred to two expert panels (one for adults, one for pediatrics), which deliberated to determine whether (and how many) quality-adjusted life-years (QALYs) were gained by helicopter as compared with alternative transport. Information about alternative transport, either by ground or by boat, was obtained by contacting the referring general practitioners.

**Setting** The study HEMS program, based at University Hospital of Tromsø, was staffed by a physician/paramedic crew and performed transports in sparsely populated northern Norway. Study patients were transported to Tromsø.

**Time Frame** Study patients were 370 rural transports occurring between January 1989 and December 1990.

**Patients** The patients were pediatric and adult (including pregnant). Most transport requests (88%) were made by general practitioners, who provided pre-transport treatment in 68% of all cases. The most common diagnosis in patients under 15 years of age was infectious (49%); cardiovascular disease was the transport diagnosis in 50% of adults. Trauma accounted for 20% of both adult and pediatric transports. There was no simultaneously transferred ground EMS comparison group.

**Analysis** Statistical analysis was primarily descriptive.

**Results** As judged by estimated times, patients arrived an average of 69 minutes earlier by traveling by helicopter as compared with other means. For 283 cases (76%), it was decided that helicopter transport offered no benefit since no treatment was given during transport or early after arrival at University Hospital. The remainder of patients entered the panel evaluation system, which found an overall benefit existed for 41 (11% of 370) patients who accrued a total of 290.6 life-years gained due to helicopter transport. Nearly all (96%) of the life-years gained were by nine patients, six of whom were below the age of 7 years. The life-year gain per adult patient with cardiovascular disease was 0.54.

**Authors' Conclusions** HEMS can provide considerable health benefits for selected patients in the rural setting studied. Since 89% of patients did not benefit from HEMS transport, the costs and risks of HEMS are associated with relatively low benefits for most patients.

**Commentary** This study used a technique more rigorous than most using the "expert panel" approach and should be read in full for an appreciation of its methods and results. Another strong point of the study was the use of a commonsense endpoint, need for urgent intervention at the receiving institution, to assist in assessing HEMS utilization appropriateness. This endpoint, while still imperfect, may in fact be a better measure than often-used criteria such as 24-hour discharge (the latter criterion can miss patients who needed urgent diagnostic interventions for potentially life-threatening processes). Despite its strengths, the paper suffers from difficulties inherent to "looking through the retro-spectroscope." The authors note that 53 flights, done without a doctor on board, were excluded from analysis because these flights were done on non-seriously ill patients "for

convenience"; if these patients were included, the analysis would yield lower health benefit per patient or flight.

- Snooks HA, Nicholl JP, Brazier JE, Lees-Mlanga S. The costs and benefits of helicopter emergency ambulance services in England and Wales. *J Public Health Med.* 1996;18:67-77.

**Objective** The study's objective was to assess ground and air prehospital care system performance, and analyze costs and health benefits associated with HEMS use.

#### Methods

**Study Design** The study was a retrospective review of prehospital transport and hospital records and long-term disability benefit. Not all phases of the study design were available from all three study settings. Issues related to study design and other methodology components of this complex study can be fully elucidated only by a reading of the full paper.

**Setting** There were three study settings, each of which was characterized by availability of ground and air transport. The three study sites were Cornwall, Sussex, and London; HEMS crew configurations were different in the three settings. Ground transport was performed by nonphysician crew.

**Time Frame** Study patients were transported over different time frames in the three study settings.

**Patients** The HEMS group were patients of all diagnoses flown by helicopter. For the London setting, patients were primary (scene) transports with the following diagnostic breakdown: 48% were motor vehicle collision victims, and the remainder were victims of falls, suicide (mechanism not given), assaults (no other mechanism details given), fire, burns, drowning, and "other" trauma. In the Cornwall setting, most patients were trauma victims, but a third were either cardiac patients or patients undergoing interhospital transfer (not clearly defined as to medical/surgical diagnosis). In the third setting, in Sussex, nearly all patients were trauma patients; this was the group for whom Injury Severity Score (ISS) was not assessed. In all three groups, the ground EMS comparison group was constituted of patients of supposedly similar acuity and diagnosis; no statistical analysis was presented to support this contention. With regard to patient acuity, decision on transport mode was made by different means in the three systems; no protocols were given in the paper.

**Analysis** Statistical analysis was reported by the authors to control for multiple factors, but no specifics of statistical methodology were given in the paper.

**Results** No specific statistical results (e.g., relative risks, confidence intervals, multivariate models) were reported. HEMS use was not associated with improvements in response times, and scene times for HEMS-transported patients were longer than those with ground transports. Survival was not improved with HEMS transport. Levels of residual disability were significantly different between HEMS and ground transports in only one study setting (Cornwall), where this outcome was improved in HEMS patients. Overall, HEMS transport was not associated with improvement in health status or aspects of daily living. The authors provide extensive other (non-outcome) details in the Results section.

**Authors' Conclusions** In trauma patients, there was no overall mortality benefit associated with HEMS use, and

morbidity improvement was limited or nonexistent. For coronary emergencies, there was no evidence that HEMS utilization was associated with outcome benefit. HEMS is costly and is associated with small, if any, health benefit.

**Commentary** This paper, quoted with some frequency in the HEMS literature, had ambitious goals: assessment of the processes of care as well as cost-benefit analysis. Multiple endpoints were assessed over different lengths of time at three HEMS programs that differed with respect to geography, patient mix, crew configuration, and dispatching/triage. Therefore, the authors' task was daunting and their success was mixed at best. Since crude mortality for HEMS patients is expected to be higher than that for ground patients, a study such as this must carefully adjust for acuity. For one group of patients, the injured, ISS was used. However, ISS—apparently the only numerical severity grade used in the study—was available for only two of three study programs. Analysis was not limited to one specific diagnostic category and the authors failed to explain their methods of accounting for diagnostic differences. On a note related to diagnostic category, ISS appears to have been used to characterize severity in patients where this parameter is of unclear applicability: "suicide" (no mechanism given), assault, drowning, and fire. Additionally, it was surprising to note a complete absence of delineation of statistical methodology or results. The statistical tests used were not stated, and the paper was devoid of reports of relative risk, confidence intervals, or p-values. Transport mode selection was not rigorously performed (or explained) and the table outlining HEMS interventions ("doctor skills") did not include endotracheal intubation. The authors' data as reported cannot be invoked to prove their contention that HEMS was unassociated with outcome improvement.

- Arfken CL, Shapiro MJ, Bessey PQ, Littenberg B. Effectiveness of helicopter versus ground ambulance services for interfacility transport. *J Trauma.* 1998;45:785-90.

**Objective** The study's objective was to compare, for a group of patients for whom air medical transport was requested but not necessarily performed, outcomes between helicopter- and ground-transported patients.

#### Methods

**Study Design** The study was a prospective analysis of dispatch, flight, and hospital records. There was also a survey component for determination of post-transport health/disability status. The investigators reduced patient acuity bias inherent to ground vs air comparisons by having the ground-transported group constituted of patients for whom helicopter transport was requested but unavailable.

**Setting** The study HEMS program, ARCH Air Medical Services of St. Louis, was staffed by nurses and paramedics; flights requiring specialty medical crews were excluded. Based on historical data, 61% of all ARCH flights were to the hospitals comprising the receiving centers in the study. A small number (25) of patients were transported by one of four other HEMS services.

**Time Frame** Study patients were transported between April 1994 and July 1995.

**Patients** The study included those ARCH flights involving interfacility transport to one of five teaching hospitals in St. Louis. Adult patients (at least 17 years of age) of all diagnoses were included.

**Analysis** Statistical analysis was primarily performed with logistic regression-determined adjusted mortality odds ratios. Multivariate analysis took into account older age, female sex, minority status, location of requesting hospital, and acute illness severity. Illness severity was assessed by the Rapid Acute Physiology Score (RAPS), which is based on the Acute Physiology and Chronic Health Evaluation II (APACHE II), uses the Glasgow Coma Score, mean arterial pressure, respiratory rate, and heart rate.

**Results** Of the 1,461 requests for helicopter transport, 1,412 were transported by ARCH, 153 were transported by ground, and 25 were transported by non-ARCH HEMS services. All but five patients were transported with ALS-level attendants. Univariate analysis revealed similar RAPS scores between groups, with other variables (e.g., race) differing between groups. ARCH-transported patients arrived at receiving hospitals in an average of 1.5 hours, compared with ground EMS-transported patients' average of 3.7 hours. Crude mortality was 19.5% for ARCH patients, 14.8% for ground EMS patients, and 4.2% for patients transported by other HEMS services. When patients who had HEMS requests cancelled for medical reasons (i.e., not due to weather or aircraft unavailability) were eliminated from consideration, the mortality rates for ARCH, ground, and other HEMS were 19.5%, 15.2%, and 0%, respectively. Multivariate analysis failed to identify HEMS transport as a significant contributor to survival.

**Authors' Conclusions** Patients transported by helicopter did not have improved outcomes compared with patients transported by ground. The data argue against a large advantage accrued with helicopter transport.

**Commentary** This study was conducted with statistical rigor, but the conclusions that can be definitively drawn from it are limited due to other, more clinical, methodological quirks. The most important of these is the pooling of trauma, cardiac, and other diagnoses into one study population. The use of the RAPS score to generate a pooled acuity estimate is rarely encountered in the HEMS literature, and the supporting "validating research" cited by the authors consists of two papers by the same primary author, based on data from the 1980s. Interestingly, the authors' prospectively planned study did not incorporate an indexed variable for "diagnostic category" into their logistic regression models. The authors' discussion includes delineation of other clinical limitations to their study, including a strong possibility of residual confounding due to intergroup acuity differences.

- Werman HA, Falcone RA, Shaner S, et al. Helicopter transport of patients to tertiary care centers after cardiac arrest. *Am J Emerg Med.* 1999;17:130-4.

**Objective** The study's objective was to evaluate the survival benefit of helicopter transport of rural patients status-post cardiopulmonary resuscitation (CPR) for nontraumatic arrest.

#### Methods

**Study Design** The study was a retrospective review of flight and medical records. Outcomes were not compared with a contemporary ground transport group, but there was discussion comparison between study group outcomes and historical data from other investigations of similar ground-transported patients.

**Setting** The study HEMS programs, based at Ohio State

University College of Medicine and Grant/Riverside Methodist Hospital, were both staffed by a nurse/paramedic crew and performed transports in southeastern Ohio; patients were transported to several adult and pediatric tertiary care centers in the region.

**Time Frame** The study included 170 scene and interfacility transports occurring between January 1990 and March 1994.

**Patients** Patients were eligible if they had suffered nontraumatic cardiopulmonary arrest requiring CPR, had been successfully resuscitated, and had a perfusing rhythm prior to transport. The majority of patients were either children (under 18 years of age) or mature adults (older than 45 years). Primary cardiac disease accounted for 43% of the patients, near-drowning 24%, and noncardiac medical illnesses 21%, with the remainder of the patients having suffocation, electrocution, or smoke inhalation.

**Analysis** Statistical analysis was descriptive, with comparative analysis of survivors vs nonsurvivors.

**Results** Only one significant difference was identified in comparison of survivors with nonsurvivors. Survivors were older largely because their cardiopulmonary arrest was more frequently of primary cardiac origin. Compared with historically reported ground-transported patients, HEMS-transported patients with primary cardiac etiology for their initial arrest had a relatively high (45%) rate of long-term survival. Patients with other diagnoses had much lower survival rates (e.g., 15% for drowning). The HEMS crews frequently provided advanced therapeutic interventions in this transport population.

**Authors' Conclusions** In patients who have been stabilized after cardiac arrest due to primary cardiac etiology, HEMS transport for tertiary care is associated with a relatively high survival rate. Long-term survival for other nontraumatic arrest diagnoses is low, and further investigations should focus on identification of which of these groups are most likely to warrant HEMS transport.

**Commentary** This paper's results support the authors' appropriately limited conclusions. A reasonable interpretation of those conclusions would be that, for at least some nontrauma diagnoses, HEMS transport of high-acuity (i.e., post-arrest) patients is not an inherently futile utilization of resources. Patients on the "bubble" will always represent difficult transport decisions. For example, the younger near-drowning patients had poor overall survival—15%—but all of those who did survive were completely neurologically intact. Additionally, some "drowning" patients with poor outcomes may have had associated high cervical spine injuries, confounding the ability to assess outcomes. As is the case for many other patient populations, the decision to utilize HEMS transport for post-arrest patients is likely best made on a case-by-case basis.

- Hotvedt R, Kristiansen IS. Doctor-staffed ambulance helicopters: to what extent can the general practitioner replace the anesthesiologist? *Br J Gen Pract.* 2000;50:41-2.

**Objective** The study's objective was to analyze health benefits associated with HEMS transport, and to determine whether flight anesthesiologist crew members could be replaced with general practitioners without loss in HEMS-associated health benefits.

#### Methods

**Study Design** The study was a retrospective review of flight

and medical records, with use of a panel technique to assess mortality benefit associated with HEMS transport.

**Setting** The study HEMS program, based at University Hospital of Tromsø, was staffed by an anesthesiologist/paramedic crew and performed transports in sparsely populated northern Norway. Study patients were transported to Tromsø.

**Time Frame** Study patients were transported between January 1989 and December 1990.

**Patients** The HEMS group were all patients transported during the study period for whom it was determined that HEMS was lifesaving. Approximately half of the 41 patients whose lives were adjudicated to have been saved by HEMS were cardiac patients; a fifth were trauma patients and the rest had a myriad of medical, obstetric, and environmental problems.

**Analysis** Statistical analysis was primarily descriptive.

**Results** There were 41 patients (11.1% of all flights) adjudicated to have had their lives saved by HEMS transport; in 29 of these cases (70.7%) the flight crew anesthesiologist performed interventions critical to patient survival. Overall, the expert panel decided that for three of the 29 cases (10.3%), the patient would have died without the specialist skills of the flight anesthesiologist.

**Authors' Conclusions** The specialized skills of a flight anesthesiologist are an important, though relatively infrequent, contributor to mortality benefit associated with HEMS transport.

**Commentary** The crux of this study was to determine optimal crew configuration rather than analyze mortality benefit. The crew configuration debate, characterized by a level of controversy inversely proportional to the quality of extant data, is beyond the scope of discussion here. However, assessment of mortality benefit was a definitive component of the authors' study. The finding of 41 saved lives must be considered in light of the facts that mortality benefit seemed to have been virtually assumed by the authors, and the study employed an inherently subjective technique for health benefit determination. Importantly, any HEMS benefit found in this study could have been a function of crew abilities, rather than helicopter transport itself. Finally, it should be noted that this study appeared to examine a subset of a patient population from another study (reviewed above) by Hotvedt et al.

## CARDIAC

- Topol EJ, Fung AY, Kline E, et al. Safety of helicopter transport and out-of-hospital intravenous fibrinolytic therapy in patients with evolving myocardial infarction. *Cathet Cardiovasc Diagn.* 1986;12:151-5.

**Objective** The study's objective was to assess safety and utility of HEMS for expediting access to tertiary care for patients with evolving coronary syndromes.

### Methods

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

**Setting** The study HEMS program, at the University of Michigan (UM), was staffed by a physician/nurse crew and transported the study patients an average of 55 miles to the Cardiac Catheterization Center at UM.

**Time Frame** Study patients were transported between December 1983 and December 1985.

**Patients** The HEMS group were 150 consecutive patients with acute myocardial infarction (AMI) transported by HEMS for acute intervention. Fifty-five of the patients (36.7%) had had intravenous thrombolytic therapy initiated prior to transport. There was no ground EMS comparison group.

**Analysis** Statistical analysis was primarily descriptive, with analytical comparison of characteristics between patients who underwent pretransport lysis and those who did not.

**Results** There were no deaths, hemorrhage, or hemodynamic instability during transport. Patients who had received thrombolytic therapy had a higher incidence of intratransport arrhythmias than non-lysed patients, but no patient required cardioversion, pacing, or new antiarrhythmics during HEMS transport.

**Authors' Conclusions** Helicopter transport of patients with evolving AMI is safe, and HEMS has "tremendous potential" to make the aggressive interventional cardiac therapy widely available.

**Commentary** This paper, one of a few reviewed here from the same group in Michigan, set out to address the safety of early initiation of thrombolytic therapy, with a parallel aim of assessing safety of HEMS transport of patients during early AMI. Demonstration of HEMS transport safety in a group of patients with active myocardial ischemia was important. However, the authors were appropriately conservative in their call for thorough cost-benefit analysis before generalized use of HEMS for cardiac patients.

- Kaplan L, Walsh D, Burney RE. Emergency aeromedical transport of patients with acute myocardial infarction. *Ann Emerg Med.* 1987;16:55-7.

**Objective** The study's objective was to determine whether helicopter transport of patients with AMI resulted in high mortality.

### Methods

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

**Setting** The study HEMS program, the University of Michigan aeromedical service, was staffed by a physician/nurse crew and performed transports within a 150-mile radius of the tertiary care center.

**Time Frame** Study patients were transported over the period May 1983 to December 1984.

**Patients** The HEMS patients were 104 patients with a diagnosis of suspected AMI who underwent interfacility transport. All were transported within 36 hours of onset of symptoms, and most were enrolled in clinical investigations of thrombolysis or emergency angioplasty. Acute myocardial infarction was ultimately confirmed in 94% of the patients. Emergency intervention was performed in 72% of cases, and 87% of the patients survived to hospital discharge. There was no ground EMS comparison group.

**Analysis** Statistical analysis was limited to descriptive reporting of patient characteristics and outcomes.

**Results** There were no deaths during transport. Thirteen patients (12%) suffered intratransport complications, including nine with hypotension and four with new arrhythmias.

**Authors' Conclusions** The study concluded that emergency transport of patients with AMI can be carried out safely with aeromedical transport, which thus "expands the availability of regional resources for cardiac care."

**Commentary** This was one of the earliest studies to address the question of whether there was some intrinsic medical risk associated with helicopter transportation of patients with AMI. The study patients had a high rate of ultimate diagnosis of myocardial infarction, and thus constituted a group with relatively high potential for both intratransport complications and possible benefit from HEMS transport. In the absence of a control group, the authors' results would appear to support only a contention that HEMS transport does not result in substantial mortality increase for patients with AMI.

- Topol EJ, Bates ER, Walton JA, et al. Community hospital administration of intravenous tissue plasminogen activator in acute myocardial infarction: improved timing, thrombolytic efficacy and ventricular function. *J Am Coll Cardiol.* 1987;10:1173-7.

**Objective** The study's objective was to analyze outcomes in patients presenting to community hospital EDs who received tissue plasminogen activator (tPA) prior to or after transport to a university center.

#### Methods

**Study Design** The study was a retrospective review of transport and hospital records. Patients were categorized as to time of tPA administration: group I patients received tPA only after transport to the tertiary facility, group II patients had tPA administered by HEMS physicians who transported the medication to the patient, and group III patients received early tPA on their presentation at the community hospitals.

**Setting** Patients were transported to the University of Michigan Medical Center from two of its affiliated community hospitals, located 37 and 54 miles from Ann Arbor. The University of Michigan HEMS program, staffed by a physician/nurse crew, transported all 70 patients comprising group II (HEMS crew-initiated tPA) and 43 (of 53) patients in group III (early tPA at community hospitals). Transport mode for group I patients ( $n = 19$ ) was not given, and no details about ground transport were provided in the paper.

**Time Frame** The study's time frame was not delineated.

**Patients** The patients represented 142 consecutive transfers from the two community centers to the University of Michigan for interventional cardiology after tPA.

**Analysis** Statistical analysis was analytic. Because of the small number ( $n = 19$ ) of patients in group I (those receiving tPA after transport to the University of Michigan), this group and group II (tPA administered by the HEMS crew,  $n = 70$ ) were pooled for comparison vs group III (tPA upon patient arrival at the community hospital,  $n = 53$ ). Outcomes assessed were: vital status, interventions [e.g., percutaneous transluminal coronary angioplasty (PTCA), coronary artery bypass grafting (CABG)], time-related, and anatomic/physiologic (e.g., left ventricular ejection fraction).

**Results** There were no deaths during transport, and overall mortality rates were similar for the three groups. Time from chest pain onset to tPA administration was significantly shorter for group III patients compared with the pooled groups I and II. Ejection fraction was higher in group III as compared with the other groups. There was a near-significant ( $p = 0.057$ ) finding of increased recanalization in group III as compared with group I/II patients.

**Authors' Conclusions** The authors concluded that early

tPA administration was safe, and associated with benefit compared with tPA administration by HEMS crews or cardiologists at the receiving center.

**Commentary** The constitution of the three groups was determined by time frame of presentation. Patients in group I were those who presented to the community hospitals before tPA was available, those in group II presented while HEMS crews (but not the community hospitals themselves) had access to tPA, and group III patients presented to the community hospitals after tPA was available for immediate use. The study demonstrates the feasibility of HEMS-crew administration of tPA, but suggests that the better approach is to provide tPA early after community hospital presentation.

- Tyson AA, Sundberg DK, Sayers DG, Ober KP, Snow RE. Plasma catecholamine levels in patients transported by helicopter for acute myocardial infarction and unstable angina pectoris. *Am J Emerg Med.* 1988;6:435-8.

**Objective** The study's objective was to determine whether catecholamine levels rose from pretransport levels, during HEMS transport of cardiac patients.

#### Methods

**Study Design** The study was a prospective analysis of flight records and catecholamine levels. For some patients preflight and inflight plasma epinephrine and norepinephrine levels were determined. All patients were monitored for ventricular arrhythmias.

**Setting** The study HEMS program, AirCare, was staffed by a nurse/paramedic crew and performed transports in largely rural North Carolina. The study patients were transported to North Carolina Baptist Hospital in Winston-Salem.

**Time Frame** The study was conducted over a one-month period in 1987.

**Patients** The HEMS group were 14 consecutive adult patients with AMI or unstable angina transported during the study period. There was no ground EMS comparison group.

**Analysis** Statistical analysis focused on changes in catecholamine levels.

**Results** The mean inflight plasma epinephrine level was significantly higher than the mean preflight level (3455 vs 841 pg/mL). There was a trend toward higher inflight norepinephrine levels, but the increase failed to reach statistical significance.

**Authors' Conclusions** Helicopter transport of cardiac patients may be associated with significant patient stress as reflected by high inflight (as compared with preflight) catecholamine levels.

**Commentary** The authors of this interesting study did not find any clinical correlation to their results; no patients in their small series had ventricular arrhythmias. Additionally, while the authors provided good explanation for their choice of study diagnosis, the fact that the study focused on cardiac patients limits the generalizability of the results to noncardiac diagnoses (in which catecholamine elevation is less likely part of the natural history of evolving disease). This paper provided impetus for assessments of whether HEMS was associated with high intratransport complication rates.

- Bellinger RL, Califf RM, Mark DB. Helicopter transport of patients during acute myocardial infarction. *Am J Cardiol.* 1988;61:718-22.

**Objective** The study's objective was to determine whether helicopter transport of patients with AMI resulted in high mortality.

#### Methods

*Study Design* This was a prospective study in which patients' conditions were monitored during transport, and intratransport complications were noted.

*Setting* The study HEMS program, at Duke University, was staffed by a nurse/nurse crew and performed transports within a 150-mile radius of the tertiary care center.

*Time Frame* Study patients were transported over a 15-month period in 1985–1986.

*Patients* The HEMS patients were 250 patients with a diagnosis of suspected AMI who underwent interfacility transport. All were transported within 12 hours of onset of symptoms, and all underwent cardiac catheterization upon arrival at Duke. Thrombolytic therapy (usually streptokinase) was administered to 96% of the study patients; in 70% of these cases lysis was begun prior to HEMS transport from community hospitals and may have continued during flight, in 5% of cases lytic agents were instituted during transport, and in the remaining 25% thrombolysis was given upon arrival at Duke. There was no ground EMS comparison group.

*Analysis* Statistical analysis was limited to descriptive reporting of patients' clinical courses.

**Results** Though no comparative statistical analysis was performed, descriptive statistics showed that major complications (i.e., ventricular fibrillation, sustained ventricular tachycardia, second- or third-degree atrioventricular block, asystole, sustained hypotension, respiratory arrest) were much more common in the preflight ( $n = 92$  occurrences) as compared with the inflight ( $n = 15$ ) time frame. There were no deaths during transport.

**Authors' Conclusions** The authors concluded that HEMS transport of patients with AMI, including those receiving thrombolytic agents, was not associated with significant risks. The authors also emphasized the relatively infrequent inflight complication rate, and suggested that patients with preflight complications could have particularly benefited from air transport given the shorter out-of-hospital times in helicopter vs ground vehicle.

*Commentary* This study set out to determine whether HEMS transport was associated with a high adverse event rate, when a large proportion of patients received thrombolytics either before or during flight. Given theoretical concerns about helicopter-related effects (e.g., from airframe vibrations) on thrombolytic complication rates, the study's findings represented an important step. However, there was no mention of hemorrhagic complications (e.g., stroke), and the lack of a ground EMS comparison group limits concrete conclusions that can be drawn from the study data.

- Rodgers G, Ruplinger J, Spencer W, et al. Helicopter transport of patients with acute myocardial infarction. *Tex Med.* 1988;84:35-7.

**Objective** The study's objective was to assess the safety and utility of HEMS transport for patients with AMI.

#### Methods

*Study Design* The study was a prospective review, with historical controls, of flight and hospital records.

*Setting* The study HEMS program was staffed by a cardiologist (fellow) and nurse crew and performed transports

within a 200-mile radius of Houston. The study patients were transported to Methodist Hospital.

*Time Frame* Study patients were transported between March 1987 and November 1987.

*Patients* The HEMS group were the 161 patients with AMI transported during the study period. Fifteen percent of the patients were in cardiogenic shock and 18% had malignant arrhythmias; 47% received thrombolysis at referring hospitals prior to HEMS transport. There was no ground EMS comparison group. Outcomes comparisons were made against ground-transported patients' outcomes as reported in previous literature.

*Analysis* Statistical analysis was primarily descriptive. There was no analytic comparison of outcomes between HEMS and the historical controls alluded to in the paper.

**Results** There were no deaths during transport; three patients were successfully resuscitated from cardiac arrest during helicopter flight. The mortality for patients in cardiogenic shock was high (64%); this was in line with previous literature on mortality in similar patients transported by ground. Of the remaining 147 patients (not in shock during transport), the overall mortality was 4%; this was noted by the authors to be lower than expected based on their review of previous literature.

**Authors' Conclusions** HEMS allowed a "100% safe" system for access to cardiac tertiary care. For those not in shock, the in-hospital mortality of HEMS-transported cardiac patients "compares favorably to any control group previously reported in the literature." Patients who have received thrombolysis can be safely transported to tertiary care without concern for increased complications.

*Commentary* The authors' conclusions were appropriately tempered by their statement that their observations lacked the power of comparison with a contemporary control group. However, their paper did provide evidence of safety, and possible outcomes improvement, associated with HEMS transport of patients with AMI.

- Schneider S, Borok Z, Heller M, Paris P, Stewart R. Critical cardiac transport: air versus ground? *Am J Emerg Med.* 1988;6:449-52.

**Objective** The study's objective was to determine the impact of air, as opposed to ground, EMS transport of critical cardiac patients.

#### Methods

*Study Design* This was a retrospective study in which patients' intratransport courses were analyzed and categorized as to frequency of occurrence of serious untoward events or other untoward events. Serious untoward events were defined as any of the following: new arrhythmia or worsening of previously noted arrhythmia, recurrence or worsening of chest pain, hypotension, bradycardia, cardiac arrest, respiratory arrest, or major motor seizure. Other untoward events were: new-onset nausea or vomiting, equipment failure, or loss of intravenous line.

*Setting* The study transport program, at the University of Pittsburgh, was staffed by a physician and either a nurse or a paramedic. The same program (with the same crew configuration) performed both air and ground transports and all patients were transferred to the same receiving center.

*Time Frame* The paper does not specifically give the dura-

tion or year of the study, but patients appear to have been transported in 1985.

**Patients** The study population consisted of 78 consecutive interfacility transports, 27 by ground and 51 by air, of patients with the diagnosis of AMI or unstable angina.

**Analysis** Univariate analysis compared the numbers of patients in ground and air transport groups suffering at least one untoward event.

**Results** Ground and air transport groups were similar with regard to age, sex, Killip classification, and diagnosis (myocardial infarction or angina). Four of 51 (7.8%) air-transported patients were intubated prior to transport, as compared with five of 27 (18.5%) ground patients. [Though the authors report these proportions as significantly different, such a difference is not identified by calculations done for this review using Fisher's exact test ( $p = 0.26$ ) or risk ratio analysis (95% confidence interval, 0.12–1.45).] During transport, air patients were much more likely than ground patients (49% vs 14.8%) to suffer untoward events of all types, to suffer serious untoward events (41.2% vs 7.4%), and to require interventions such as intravenous line placement or medication administration (41.5% vs 14.8%).

**Authors' Conclusions** HEMS transport of acute cardiac patients may be associated with more untoward events than ground transport of equal duration, and ground transport may be an alternative to air transport. The reasons for the observed differences in complication rates, and their influence on eventual outcome, were noted to be unknown.

**Commentary** The data from this study are consistent with an adverse effect of HEMS transport on cardiac patients. However, an equally plausible explanation for the study's findings is that patients transported by HEMS were of higher acuity than the ground group, and thus naturally had more complications. Patients were selected for ground or air transport in nonblinded fashion by emergency medicine attending physicians, who likely tended to send "sicker" patients by air. This critical shortcoming of the study, as discussed by the authors, is exacerbated by the unavailability of a well-accepted acuity stratification (with enabling of multivariate analysis) for the study's patients; simple categorization by Killip classification is not likely adequate. Unfortunately, the lack of ability to accurately stratify cardiac patients' pretransport acuity (i.e., with a score analogous to the Injury Severity Score or Revised Trauma Score for trauma patients) represents a substantial hurdle for studies of this type.

- Gore JM, Corrao JM, Goldberg RJ, et al. Feasibility and safety of emergency interhospital transport of patients during early hours of acute myocardial infarction. *Arch Intern Med.* 1989;149:353-5.

**Objective** The study's objective was to assess the efficacy of a cardiac transport system, consisting of ground and helicopter vehicles, in transferring early AMI patients from community hospitals to tertiary care.

#### Methods

**Study Design** This was a retrospective study in which patients' conditions were monitored during transport, and intratransport complications were noted.

**Setting** The study tertiary care center, the University of Massachusetts Medical Center, had a 130-mile catchment area. The UMass LifeFlight HEMS program was staffed by

an emergency medicine physician and a nurse. Ground-transported patients were accompanied by an attending cardiologist and/or critical care nurse from the referring facility.

**Time Frame** Study patients were transported between April 1985 and May 1986.

**Patients** The study patients were 57 patients in the early hours of AMI receiving interfacility transports, 23 by ground and 34 by HEMS. Patients were transported to the UMass Medical Center for participation in an early phase of the Thrombolysis in Myocardial Infarction (TIMI) thrombolysis trial. Decision as to air or ground transport mode was made by the attending physician in the UMass Coronary Care Unit in consultation with referring physicians.

**Analysis** Statistical analysis was limited to descriptive reporting of patients' clinical courses.

**Results** No deaths occurred during transport. Though the authors did no comparative analysis, it appeared that air-transported patients had higher rates of complications (chest pain, hypotension, or arrhythmia) both before and during transport. In both air- and ground-transported patients, the primary complication was recurrence of chest pain, which occurred in 72% of patients overall.

**Authors' Conclusions** A transport system of air and ground ambulances provided a safe and effective means to transport cardiac patients in the early stages of AMI. The authors felt that the HEMS and ground crews provided intratransport therapy that was of clinical benefit, and suggested that HEMS and ground transport offered an important modality for getting AMI patients to centers offering potentially lifesaving cardiologic intervention.

**Commentary** This study did not address air vs ground outcome; it was rather designed to demonstrate the overall safety and efficacy of the air/ground cardiac transport system. The authors did not comment on the different complication rates in air and ground patients, noting that transport mode was affected by patient condition. It is important to note that in the ground transport mode, the crew was provided by the referring facility, which may have decreased the speed advantage of HEMS transport. The availability of attending cardiologists as ground transport crew (as was done in some of the ground transports in this study) is likely very low in most regions of the country.

- Vukov LF, Johnson DQ. External transcutaneous pacemakers in interhospital transport of cardiac patients. *Ann Emerg Med.* 1989;18:738-40.

**Objective** The study's objective was to assess the incidence, efficacy, safety, and impact on patient outcome of using an external pacemaker by a HEMS service.

#### Methods

**Study Design** This was a prospective study in which patients' conditions and complications were followed before, during, and after air transport.

**Setting** The study tertiary care center, the Mayo Clinic, accepted cardiac transports from multiple small community hospitals. The Mayo HEMS program was staffed by a nurse/nurse crew.

**Time Frame** Study patients were transported between October 1985 and April 1988.

**Patients** The study patients were drawn from a group of 297 patients with presumed unstable angina, AMI, or perma-

nent pacemaker failure, undergoing interfacility transport to the Mayo Clinic.

**Analysis** Statistical analysis was limited to descriptive reporting of patients' clinical courses.

**Results** No deaths occurred during transport. Ultimately, 11 patients required intratransport external pacing due to in-flight deterioration (six patients), failure of temporary transvenous pacers (two patients), or failure of pretransport attempts at transvenous pacer placement (three patients). Another patient failed capture with external pacing and ultimately died from what proved to be a pulmonary embolus. In six patients, external pacing during flight successfully treated pulseless patients with bradycardia. There were no complications noted from external pacing, and no equipment malfunction occurred.

**Authors' Conclusions** The authors concluded that external pacing capability was an important component of optimal interhospital cardiac care, and that HEMS crews were able to apply this modality with a high rate of success and no apparent technical problems.

**Commentary** This study demonstrated the viability of external pacemaker application and function during air transport. While the feasibility of external pacing during HEMS transport is now accepted, such was not always the case, and thus papers such as this are an important part of the literature.

- Fromm RE, Hoskins E, Cronin L, et al. Bleeding complications following initiation of thrombolytic therapy for acute myocardial infarction: a comparison of helicopter-transported and nontransported patients. *Ann Emerg Med.* 1991;20:892-5.

**Objective** The study's objective was to evaluate the effect of HEMS transport of AMI patients after initiation of thrombolysis, on bleeding complications through hospital discharge.

#### Methods

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

**Setting** The study HEMS program, Methodist Hospital Aeromedical Services, was staffed by a physician/nurse crew and performed transports within 200 miles of Houston. The study patients were transported to Methodist Hospital.

**Time Frame** Study patients were transported over the period March 1987 through March 1989.

**Patients** The HEMS group were 95 consecutive AMI patients HEMS-transported within 12 hours of thrombolysis initiation. Outcomes comparisons were made against 119 nontransported patients treated in similar fashion.

**Analysis** Statistical analysis was univariate analytic comparison of complications occurring in the air-transported vs nontransported groups.

**Results** The HEMS and nontransported groups were similar with respect to age, sex, and infarct location. There were no arrests or requirements for cardioversion during flight. Bleeding complications occurred in 43.2% of transported and 49.6% of nontransported patients (relative risk 0.87, 95% CI 0.65 to 1.17).

**Authors' Conclusions** HEMS transport of AMI patients after thrombolysis initiation appears to be safe acutely, and is not associated with an increased risk of bleeding complications through hospital discharge.

**Commentary** This well-designed and executed study went far toward demonstrating the safety—at least for bleeding complications—of HEMS transport of patients after thrombolysis administration.

- Fromm RE, Taylor DH, Cronin L, McCallum WB, Levine RL. The incidence of pacemaker dysfunction during helicopter air medical transport. *Am J Emerg Med.* 1992;10:333-5.

**Objective** The study's objective was to assess the incidence and clinical impact of pacemaker dysfunction occurring during HEMS transport.

#### Methods

**Study Design** This was a retrospective study in which patients' intratransport complications were assessed.

**Setting** During the study period, the Aeromedical Services of the Methodist Hospital provided transport services for 1,715 cardiac patients (72% of their total of 2388 flights), from within a 200-mile radius of the Texas Medical Center in Houston.

**Time Frame** Study patients were transported between April 1987 and December 1991.

**Patients** The study patients were 44 individuals undergoing intratransport pacing. Pacing methods in the 44 patients were: temporary intravenous (35), permanent (5), and transcutaneous (4). No rate-responsive pacemakers were transported. Patients connected prophylactically to pacemakers, but not actually paced, were not included in the analysis. Pacemaker dysfunction was defined as any of the following: failure to capture, failure to sense, or requirement to change pre-takeoff pacemaker settings while in flight. There was no ground-transported control group.

**Analysis** Statistical analysis was limited to descriptive reporting of patients' clinical courses.

**Results** There were no instances of pacemaker malfunction during transport. No deaths occurred during transport, and in no case of post-transport in-hospital mortality (11 of 44 patients) were pacemakers judged to be a factor. For the likelihood of pacemaker dysfunction's occurring in the population of paced patients, the authors reported a 95% confidence interval of 0% to 7%.

**Authors' Conclusions** The authors concluded that helicopter transport-associated pacemaker dysfunction was a very rare event. They qualified their conclusions by noting that no patients with "rate-adaptive" pacemakers were transported, and that this type of pacemaker (which can be sensitive to vibration) may be relatively more subject to intratransport dysfunction.

**Commentary** This paper, from one of the busiest cardiac transport HEMS services programs in the United States, provided solid evidence that air transport of paced patients was not associated with inordinate risk. The authors' point about limitations of their conclusions vis-à-vis rate-responsive pacers is well taken, as is their advice to HEMS crews to ascertain specific pacemaker type prior to transport.

- Straumann E, Yoon S, Naegeli B, et al. Hospital transfer for primary coronary angioplasty in high risk patients with acute myocardial infarction. *Heart.* 1999;82:415-9.

**Objective** The study's objective was to investigate the feasibility, safety, and associated time delays of interhospital transfer (including both air and ground units) of patients with AMI for primary PTCA.

## Methods

**Study Design** This was a prospective observational study in which patients' conditions and complications were followed before, during, and after primary presentation at, or air or ground transport to, the study hospital.

**Setting** The study tertiary care center, the Triemli Hospital in Zurich, accepted cardiac transports from multiple small community hospitals. The paper did not specifically state the crew configuration, but the transports occurred in an area where transport vehicles are traditionally staffed by physician/nurse teams.

**Time Frame** Study patients seem to have been transported during 1997–1998, but this is not explicitly given in the paper.

**Patients** The study patients were divided into two groups. Group A consisted of 68 consecutive patients with AMI transferred to the study center for primary PTCA. Group B consisted of 78 consecutively enrolled patients who were taken for primary PTCA after presenting initially to Triemli Hospital.

**Analysis** Statistical analysis was univariate, and consisted of comparisons of baseline characteristics, time intervals from onset of chest pain to balloon angioplasty, hospital stays, and outcomes. There was no analysis of air vs ground transports; comparative statistics analyzed transport vs primary presentation at the study center only.

**Results** Of the 68 patients in group A, 14 (20.6%) were transported by air, with the other 54 transported by ground. No deaths occurred during transport, and no patients in cardiogenic shock deteriorated during transport. As judged by the authors, patients who arrived at the study center by interfacility transport had delays both due to transportation time and due to delays in decision making upon arrival at the receiving center.

**Authors' Conclusions** Interhospital transport was feasible and safe, even for unstable patients. Streamlining of interfacility transport operations can significantly extend the "coverage area" of primary angioplasty.

**Commentary** This paper compared HEMS transport vs primary presentation at the study center. While patients undergoing interfacility transport were "sicker," outcomes were similar. Therefore, this paper suggests that transport may play an important role in cardiac transfers if primary angioplasty becomes more frequently utilized. The finding of longer decision times for PTCA in transported patients, exclusive of delays inherent to actual transport, suggests that HEMS (and other) transport services would do well to maximize communications efficiency during interfacility transfers.

## NEONATAL

- Pieper CH, Smith J, Kirsten GF, Malan P. The transport of neonates to an intensive care unit. *S Afr Med J*. 1994;84:801-3.

**Objective** The study's objective was to describe transport mode, type of patient transported, and outcome for neonatal transports.

### Methods

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

**Setting** The study was conducted at Tygerberg Hospital in

Cape Town, South Africa. The study patients were transported to this center's Neonatal Intensive Care Unit (NICU) from throughout the Cape Province of South Africa. Fixed-wing transports were accompanied by a pediatrician. Helicopter and ground transports were accompanied by "specially trained ambulance personnel" with physicians seldom present for helicopter and never present for ground transports.

**Time Frame** The study period extended from January to September 1992.

**Patients** The study examined a total of 52 infants transported to the receiving hospital NICU by fixed-wing, HEMS, or ground ambulance. Transport mode was determined by the same authority (the Metro Service Unit) in all cases and considered logistical issues but not patient acuity.

**Analysis** Statistical analysis was primarily descriptive.

**Results** There were no deaths during transport. A total of 11 infants (21% of 52) died after transport. None of the seven patients transported by fixed-wing died, one of 15 (6.7%) HEMS infants died, and ten of 30 (33.3%) ground-transported infants died. The only analytic statistic reported by the authors was a finding that surviving infants actually had a lower gestational age than nonsurvivors (nearly three-fourths of whom died from asphyxia-related pulmonary problems).

**Authors' Conclusions** The authors concluded that their data reflect a high survival rate in transported infants, and that infants were appropriately stabilized prior to transport. The authors noted that the apparent (no statistical analysis was performed) association between transport mode and survival could be due to a variety of factors, many of which were not accounted for by the study.

**Commentary** The authors appropriately refrained from making conclusive comments about associations between transport mode and outcome. However, they did contend that outcome was not likely affected by lack of physician presence on HEMS and ground transports. Given the fact that transport mode was a major study variable, it is interesting that no statistical analysis was performed. In fact, *a posteriori* analysis—the inherent limitations of which must be emphasized—reveals that the overall survival was of borderline significance by Fisher's exact testing ( $p$  of 0.06 for table with all three transport modes and  $p$  of 0.07 for table comparing HEMS and ground transport survival).

## NEUROLOGIC

- Chalela JA, Kasner SE, Jauch EC, Pancioli AM. Safety of air medical transportation after tissue plasminogen activator administration in acute ischemic stroke. *Stroke*. 1999;30:2366-8.

**Objective** The investigators sought to determine the safety of HEMS transport of patients with acute ischemic stroke immediately after or during administration of tPA.

### Methods

**Study Design** The study was a retrospective review of flight and hospital records. Data collected included neurological and systemic complications and adherence to National Institutes of Neurological Disorders and Stroke (NINDS) tPA protocols. The surveys addressed perceived reasons for HEMS transport, expected and actual treatment, and overall outcome and impression.

**Setting** There were two study HEMS programs, PennStar and Air Care, with flight crew consisting of a nurse/paramedic or nurse/physician (eight cases) crew. The study patients were transported to two study centers, the University of Cincinnati Hospital and the Hospital of the University of Pennsylvania in Philadelphia.

**Time Frame** Study patients were transported between March 1997 and March 1999.

**Patients** Study subjects were 24 patients transferred by HEMS to the study hospitals during or immediately after tPA treatment for acute stroke.

**Analysis** Statistical analysis was descriptive.

**Results** There were no neurological or systemic complications during or after transport. There were no major bleeding complications, but four patients (16.7%) had hypertension warranting treatment; nontreatment of these patients represented NINDS protocol violations. Three patients had motion sickness, one developed transient confusion, and one experienced minor bleeding.

**Authors' Conclusions** HEMS transport was not associated with bleeding complications in patients receiving stroke thrombolysis, but crew education on stroke therapy protocol is important to reduce risk of violations. Interhospital HEMS transport provides fast and safe access to tertiary centers that can provide state-of-the-art stroke therapy.

**Commentary** This paper, reminiscent of similar studies published during the early cardiac thrombolysis era, provides initial (preliminary) evidence that patients receiving stroke thrombolysis do not appear to be at risk from the vibrations and other environmental stimuli inherent to helicopter transport.

- Conroy MB, Rodriguez SU, Kimmel SE, Kasner SE. Helicopter transfer offers benefit to patients with acute stroke. *Stroke*. 1999;30:2580-4.

**Objective** The study's objective was to evaluate the role of helicopter transportation as it related to the availability of stroke therapy and patients' perceptions of care.

#### Methods

**Study Design** The study was a retrospective review of flight and hospital records, with a prospective component consisting of surveys mailed to patients. Data collected included demographics, neurological deficit, treatment, and outcome. The surveys addressed perceived reasons for HEMS transport, expected and actual treatment, and overall outcome and impression.

**Setting** The study patients were transported to the Hospital of the University of Pennsylvania (HUP) in Philadelphia. The air medical service used was presumably PennStar, the air ambulance service of HUP, which is staffed with a nurse/paramedic crew.

**Time Frame** Study patients were transported between January 1996 and December 1997.

**Patients** The study subjects were the 73 patients transferred by HEMS to the study hospital within 24 hours of stroke onset. Eight patients (11%) received pre-transport tPA; no patient received tPA at the receiving hospital, but more than half (52%) were enrolled in stroke studies. In all patients, the diagnosis of stroke was confirmed to be correct; all but two patients were managed in a specialized stroke unit.

**Analysis** Statistical analysis was both descriptive and comparative.

**Results** There were no deaths during transport; the overall in-hospital mortality rate (at HUP) was 18%. While 35 patients (48%) received no specific therapy because of one or more exclusion criteria, only rarely (3%) was exclusion due to time considerations. Most survey respondents (84%) indicated that they were transferred for consideration for therapy unavailable at referring institutions; 93% of patients believed there was a benefit from HEMS transport.

**Authors' Conclusions** Interhospital HEMS transport may benefit a substantial number of acute stroke patients by offering potential therapies and intensive management not available elsewhere.

**Commentary** This paper, from the same group as the previous citation, begins to focus on the potential benefits of timely air transport of patients who may be candidates for time-intensive stroke therapies. As stroke patients would appear to require relatively little pretransport "packaging," speed benefits of HEMS transport may be well suited to expedited transfer of such patients to stroke centers where emerging therapies are becoming increasingly utilized.

## OBSTETRIC

- Elliott JP, O'Keeffe DF, Freeman RK. Helicopter transportation of patients with obstetric emergencies in an urban area. *Am J Obstet Gynecol*. 1982;143:157-62.

**Objective** The study's objective was to summarize the initial experience of use of HEMS for transport of obstetric patients in a large urban area, analyzing outcomes, including delivery site and neonatal complications.

#### Methods

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

**Setting** The study HEMS program, Life Flight Southern California, was staffed by a nurse/nurse crew and performed transports in the Los Angeles region. The study patients were transported to Long Beach Memorial Hospital. For the study patients, one flight nurse was replaced by an obstetrician in 75 of 100 cases and by a labor and delivery obstetric nurse in an additional 14 of 100 cases.

**Time Frame** Study patients were transported beginning in 1978, over an undisclosed period.

**Patients** The HEMS group were the first 100 obstetric patients flown from community hospitals to the study center during the study period. During the study period, helicopter transport was offered to referring physicians for all emergency transports and was required in cases of advanced premature labor, severe pre-eclampsia or eclampsia, or heavy maternal bleeding. There was no ground EMS comparison group. Outcomes comparisons were made against an index group of nontransported obstetric patients presenting primarily to Long Beach Memorial Hospital.

**Analysis** Statistical analysis was primarily descriptive, covering characteristics of obstetric patients and neonates. There was analytic comparison of various maternal characteristics (e.g., association of tocolysis with cervical changes).

**Results** There were no maternal deaths during transport, and no deliveries by the HEMS crew. Upon delivery in the receiving hospital obstetric unit, two pre-viable fetuses and 12 neonates died. The neonatal mortality rate observed in the transported patients was noted to be consistent with that of nontransported patients at the same hospital, and also

with that reported in the obstetric/neonatal literature. The authors concluded that for 25 of 100 patients transported by helicopter, logistical considerations would have rendered ground transport "difficult if not impossible." Neonatal survival rates were similar for transports of patients with ruptured membranes with and without labor at the time of transport. Comparison of cervical changes failed to identify any differences between patients receiving and not receiving tocolytic therapy.

**Authors' Conclusions** Among the authors' conclusions were: 1) HEMS transport of obstetric patients in an urban area is a viable solution to the problem of traffic congestion, 2) helicopters reduce response times for patient transport, 3) neonatal outcome for transported patients was similar to that for nontransported patients at the same center, and 4) many patients who would not have been transported by ground (because of refusal by referring physicians) were transported successfully by helicopter because of the rapid response time.

**Commentary** The authors' introduction, citing improved outcomes associated with antenatal transport of high-risk patients, makes a strong case for importance of air transport of obstetric patients. This study addresses a wide variety of issues, from maternal to neonatal to economic, and provides a useful introduction to issues (contemporary to the study period) surrounding HEMS transport of obstetric patients.

- Low RB, Martin D, Brown C. Emergency air transport of pregnant patients: the national experience. *J Emerg Med.* 1988;6:41-8.

**Objective** The study's objective was to evaluate the national experience of HEMS programs' transports of pregnant patients.

#### Methods

**Study Design** The study was a prospective survey of U.S. HEMS services.

**Setting** The study HEMS programs were responding members of the American Society of Hospital-Based Emergency Air Medical Services (ASHBEAMS, the predecessor of AAMS—the Association of Air Medical Services). Sixty-six surveys were mailed; 33 surveys were returned from a disparate group of HEMS programs.

**Time Frame** Study surveys were mailed in August 1984 and programs were asked to begin prospective data collection for a six-month period commencing February 1985.

**Patients** There were 357 patients transported by helicopter; 315 of these women were in active labor during HEMS transport and 72 were in the accelerated phase of labor.

**Analysis** Statistical analysis was descriptive.

**Results** There were no instances of in-helicopter delivery; this was felt to be due to pretransport screening for appropriateness of HEMS utilization. Seven HEMS transports were reported as aborted due to rapid progression of labor, but the authors speculated that underreporting of this parameter was likely. The authors presented results demonstrating cost-effectiveness of in-utero HEMS transport of high-risk fetuses to a perinatal center.

**Authors' Conclusions** HEMS transport of high-risk obstetric patients is cost-effective and, as practiced, is not associated with significant risk of in-helicopter delivery.

**Commentary** With evidence that high-risk neonates have higher survival when delivered at tertiary centers, HEMS

services began to be asked to transport patients closer to delivery. The concern is that while delivery at the tertiary center is preferable to delivery at the community hospital, delivery during HEMS transport risks significant danger to both mother and neonate. This study was one of the earliest analyses that provided some reassurance that the use of HEMS to transport high-risk obstetric patients was not resulting in deliveries in the back of the helicopter.

- Van Hook JW, Leicht TG, Van Hook CL, et al. Aeromedical transfer of preterm labor patients. *Tex Med.* 1998;94:88-90.

**Objective** The study's objective was to assess transport times, obstetric outcomes, and related data on transfers of pregnant patients with preterm labor.

#### Methods

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

**Setting** The study HEMS program, Life Flight, appears to have been staffed by a nonphysician crew (this was not explicitly stated) and performed transports in the Galveston, Texas, region. The study patients were transported to the University of Texas Medical Branch at Galveston.

**Time Frame** Study patients were transported between June 1993 and June 1994.

**Patients** The HEMS group were 22 HEMS-transported patients with preterm labor. There was no ground EMS comparison group.

**Analysis** Statistical analysis was descriptive, and also analytic for comparison of characteristics between patients who delivered and those who did not.

**Results** There were no deliveries during transport. There were no differences between patients who ultimately delivered (after HEMS transport to the receiving center) and those whose contractions were effectively stopped, when comparing transport times, air miles transported, gravidities, parities, pretransport cervical examination findings, and contraction frequencies.

**Authors' Conclusions** HEMS has a role in transport of the preterm labor patient, but this role is attenuated by the significant cost and time delays associated with use of HEMS as compared with ground transport. Further study of outcomes changes associated with HEMS transport of preterm labor patients needs to be performed. The authors state that their study provides support for the view held "by most investigators," that maternal and fetal risks associated with HEMS transport are "at most, minimal."

**Commentary** The authors noted that a matched retrospective study of this question could not be undertaken due to patient heterogeneity and bias in transport mode selection.

## VASCULAR

- Kent RB, Newman LB, Johnson RC, Carraway RP. Helicopter transport of ruptured abdominal aortic aneurysms. *Alabama Med.* 1989;58:13-4.

**Objective** The study's objective was to assess safety and efficacy of helicopter transport of patients with ruptured abdominal aortic aneurysm (AAA).

#### Methods

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

*Setting* The study HEMS program, Life Saver of Carraway Methodist Medical Center in Birmingham, Alabama, was staffed by a physician/nurse crew and performed transports in the northern part of Alabama.

*Time Frame* Study patients were transported over the period 1981 to 1987.

*Patients* The HEMS group were the 23 patients flown from community hospitals to the study center who had a diagnosis of ruptured AAA; an additional 49 patients with ruptured AAA were transported by Life Saver to other hospitals and were not included in the analysis. There was no ground EMS comparison group.

*Analysis* Statistical analysis was limited to descriptive reporting of patient characteristics and outcomes.

**Results** There were no deaths during transport. The overall mortality in the group was 14/23 (60.9%). Based on communication between the flight physicians and the receiving vascular surgeons, eight patients (34.8%) bypassed the receiving hospital ED and were taken directly to the operating room for emergency surgery.

**Authors' Conclusions** While there was no specific analysis,

the authors stated that in comparison with their historical experience with ground EMS, helicopter transport allowed for more expeditious patient transfer, better intratransport care, and improved communications leading to better receiving hospital preparation. An argument for HEMS outcome improvement was made based on the finding that the overall outcome in HEMS patients, transported from an average of 45 miles away, was similar to survival in a contemporary group of AAA patients undergoing short-distance ground EMS transport from within city limits. The authors contended that it was "likely that several of these [HEMS] patients" would have died if transported by ground EMS.

**Commentary** This paper contains one of the earliest discussions of benefit from a direct-to-operating-room protocol for HEMS patients. Though the authors clearly believe HEMS to be an important component of mortality reduction for AAA patients, the lack of formal comparison between HEMS patients and either contemporary or historical ground-transported patients limits definitive conclusions that can be drawn from this paper.