EDITOR'S CHOICE

Is it the H or the EMS in HEMS that has an impact on trauma patient mortality? A systematic review of the evidence

Daniel P Butler, Imran Anwar, Keith Willett

Department of Orthopaedic Trauma Surgery, University of Oxford, Kadoorie Centre, John Radcliffe Hospital, Oxford, UK

Correspondence to
Dr Daniel P Butler, Academic Foundation Trainee, Department of Orthopaedic Trauma Surgery, University of Oxford, Kadoorie Centre, John Radcliffe Hospital, Oxford OX3 9DU, UK; dan.butler@doctors.org.uk

Accepted 2 March 2010

ABSTRACT

Background and aim Prehospital care of trauma patients is a matter of great debate. The optimal transport method remains undecided, with conflicting data comparing helicopter and ground emergency medical transfer. This study systematically reviews the evidence comparing helicopter and ground transfer of trauma patients from the scene of injury.

Methods A systematic literature review of all population-based studies evaluating the impact on mortality of helicopter transfer of trauma patients from the scene of injury. We searched MEDLINE, CINAHL and EMBASE from January 1980 to December 2008 and selected and reviewed potentially relevant studies.

Results A search of the literature revealed 23 eligible studies. 14 of these studies demonstrated a significant improvement in trauma patient mortality when transported by helicopter from the scene. 5 of the 23 studies were of level II evidence with the remainder being of level III evidence. Data were then entered into an evidence table and reference made to transport staffing, intubation rate, time at scene and time/distance of transfer.

Conclusions The role and structure of HEMS in a modern trauma service is a debate that is likely to continue. Prehospital care design should be specific to critical incident frequency, geographical arrangements of hospital facilities and travel times within each trauma network. It is also important to consider the benefits and capabilities of the emergency medical team separately from the transport method being considered. An effective helicopter EMS will ultimately depend on effective operating procedures and tasking protocols, clinical governance, and auditing of the helicopter EMS activity.

INTRODUCTION

Trauma is the fourth most common cause of death in the UK and the commonest cause for loss of life in the young,[1] causing considerable loss of productivity and subsequent social and economic damage.[2] The UK's National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report[1] into trauma care within the UK concluded that 'almost 60% of the patients…received a standard of care that was less than good practice', with pre-hospital care and trauma networks found to be deficient.

Within the UK, patients may be transported by ground ambulance or, less commonly, by the helicopter emergency medical service (HEMS). The first major use of helicopter transfer for trauma patients was during the Korean War. It was not until 1987 that HEMS was created in the UK. There are now more than 20 helicopter air ambulances in the UK, most of which are run by charities.

The use of helicopters in the transport of trauma patients is thought to confer a benefit through four different means:

1. To retrieve patients from remote locations.
2. Provide the option to transport the patient directly to a specialist trauma centre.
3. Facilitate rapid transport of a specialist team to the scene of injury.
4. Expedite transfer of patients between facilities (not addressed in this review).

There remains considerable debate as to whether helicopter deployment for trauma patients is cost-effective. This is partly due to conflicting reports in the research literature on the impact of HEMS on trauma mortality, the low incidence of major trauma and the high cost of airframes and support.

In this systematic review, we aim to collate the evidence on the effect on mortality of HEMS and attempt to analyse whether it is the helicopter as a transport platform or the standard of the emergency medical service that accounts for any differences seen. A pervading difficulty is that the outcome of mortality will likely be affected by the whole trauma system including the hospital, surgical and critical care facilities and cannot be ascribed to prehospital interventions alone.

METHODS

Literature retrieval

Potentially eligible studies were identified by performing a systematic search of three electronic databases: MEDLINE (using PubMed), CINAHL and EMBASE (both using the National Library of Health). The time period for study inclusion was January 1980 to December 2008. The search terms used for the MEDLINE search were: 'helicopter', 'HEMS', 'air ambulance', 'rotorwing' and 'rotorcraft'. The terms 'HEMS', 'air ambulance', 'rotorwing' and 'rotorcraft' were not recognised by the National Library of Health database and so EMBASE and CINAHL were searched using the terms: 'helicopter' and 'ambulance'. The retrieved articles were limited to English language reports.

Selection of eligible studies

The abstracts of all studies that had potentially relevant titles were reviewed. Broad inclusion criteria were applied to the methods section of these abstracts to decide which studies should be sourced. If a study's methodology could not be determined from the abstract the paper was sourced for further review. The reference list of each sourced paper was screened to identify any additional manuscripts that could be included in the review. Strict inclusion and exclusion criteria (box 1) were then applied to potentially relevant papers to decide which would be eligible for inclusion in the systematic review. If there was uncertainty as to whether a paper should be included in the review, then the senior opinion (K.W.) was decisive.

Eligible studies were then read in detail and relevant data extracted. The strength of evidence presented by each manuscript was assessed using the Oxford Centre of Evidence Based Medicine guidelines,[3] which grade evidence across five levels of study design.

Presentation of results

Each eligible study was included in a comprehensive results table. If suitable, the authors of this paper calculated a mortality OR for those papers that had sufficient data to perform such a calculation and had not reported this ratio in the manuscript. This was included to assist in the comparison of results between studies.

RESULTS

We screened 15 756 titles and identified 668 potentially relevant titles. Of these there were 133 abstracts that could potentially be included in this systematic review. This was reduced to 49 when duplicates were removed. All of these papers were sourced for further assessment. Following review of these papers, 23 eligible papers remained. The reasons for exclusion of 26 of the sourced papers was because they focused on or included interfacility transfers,[4–14] did not only recruit trauma patients,[4 15] studied HEMS triage criteria,[16 17] used disability as the outcome,[18] had unclear methodology,[19] had no comparison group,[15 20–22] did not have HEMS as the primary intervention,[23] compared two separate HEMS services,[24–27] or were simply descriptive studies.[28]

Data from the 23 eligible studies were entered into an evidence table (table 1). Consideration was given as to whether the data could be combined to complete a meta-analysis, but due to the inconsistency in patient inclusion criteria and outcome measures this was inappropriate.

Five of the included studies were of level II evidence,[33 42 43 49 50] with the remainder being of level III evidence. Of those studies included, 19 [29 34–51] compared HEMS with a ground medical transport (GMT), with 17 of these comparing the two transport modes delivering patients to the same hospital[29 34 35 37–39 42 44 46 47 51] or within an established trauma system.[40 41 45 48–50] The remaining four[30–33] compared HEMS with data from the national Major Trauma Outcome Study (MTOS). Only one eligible study assessed HEMS in the UK.[33] The other papers reported data from the USA,[30 32 34 37–41 45 46 48 51] Italy,[47 49 50] Australia,[29 31] the Netherlands,[42–44] Germany[35] and South Africa.[36]

Fourteen studies reported results that demonstrated a significant mortality rate improvement with HEMS,[29 30 32 34 36 38 40–42 45–48 50] four reported data that did not reach significance[31 35 44 49] and five did not report whether results reached significance.[33 37 39 43 51]

Box 1 Inclusion and exclusion criteria for study

Inclusion criteria:
1. Study the mortality of trauma patients transported by HEMS from the scene.
2. Needs to have a comparative group (ie, preHEMS vs postHEMS, HEMS vs ground, HEMS vs MTOS).
3. Population based studies.
4. English literature.

Exclusion criteria:
1. Level 4/5 evidence or panel based studies.
2. Studies that look at effect of HEMS on interfacility transfer.
3. Studies that compare two separate HEMS services.
4. Studies that include non-trauma patients.

EVIDENCE REVIEW

The UK NCEPOD report from 2007[1] identified prehospital care as one of several aspects of trauma care within the UK to be substandard. A major component of prehospital care is patient transport. The debate surrounding the most appropriate form of transport from the scene of injury has spanned 25 years and remains unresolved. This systematic review addresses the question of the use of helicopter EMS in the transport of trauma patients from the scene of injury and aims to provide readers with a comprehensive overview of the evidence available on this topic, upon which individuals can draw their own conclusions.

The current literature on the effect of HEMS transport on post-trauma mortality shows varying results, with four papers[31 35 44 49] showing no significant benefit; the majority show a mortality benefit with HEMS. This variation may be a result of a number of factors.

First, the early evidence comes from the 1980s and it is likely that HEMS services utilised now are very different in tasking, equipment and prehospital support. It is for this reason that early data must be interpreted with caution. Second, the studies come from seven different countries, each of which has different geography and offers different HEMS services and different trauma systems available to receive the patient. Third, there is a variety in study methodology, comparator group selection (vs MTOS or GMT) and the level of statistical adjustment for confounding variables.

If there is a true difference in trauma patient mortality between those transported from the scene by HEMS and those by the GMT service then it may be a result of a number of factors (listed below).

Transport of a physician to the scene

Depending on the training available for nurse and paramedic crews, a physician may bring an increased skill set to allow more definitive management of patients at an earlier stage. An experienced prehospital trauma physician may also bring a higher level of clinical judgement both during the initial management of patients and in deciding the most appropriate facility for the patients' subsequent treatment. Studies[14 29 34 38 46 50] have attempted to address this issue by comparing physician-staffed HEMS services with paramedic-staffed ground services, but these are, understandably, limited by the confounding factors of the transport method and the effectiveness of the receiving hospital. Assessing the benefit of transporting a physician to the scene can only be done effectively by comparing a HEMS/GMT service with and without a physician. One randomised control trial[52] did compare the outcome of blunt trauma patients randomised to a HEMS service staffed by physician/nurse crews versus paramedic/nurse crews. Both crews were trained to perform the same level of interventions and transported patients to the same level 1 trauma centre and were, therefore, compared directly. The physician-staffed HEMS crew had a mortality rate

Table 1 Table of papers for HEMS meta-analysis (scene)

Author	Grade of evidence	Study population	Study design	Inclusion criteria	Sample size	Staffing	Intubation rate	Time at scene (min)	Time and/or distance of transfer	Analysis	Adjustments	Outcomes	Findings
TRISS-based analysis of HEMS alone													
Bartolacci[29]	3	Westmead Hospital, Sydney Nurse and paramedic crew	Retrospective	Blunt trauma patients with ISS>14	77 HEMS 4 matched GMT controls per HEMS patient	HEMS — physician GMT— paramedic	HEMS —10% needed intubation on arrival to ED GMT — 37% needed intubation on arrival to ED	HEMS — 33 GMT — NS	HEMS — 18 min GMT— NS	TRISS based analysis of HEMS. (Direct mortality comparison of HEMS vs GMT)	GMT controls matched to ISS within five points	Mortality at 48 h	50% reduction in TRISS predicted mortality (p<0.001). 18 deaths predicted, nine actual deaths Adjusted W statistic of 12.18 (CI 5.3 to 19.1). (M stat=0.52) GMT vs HEMS mortality RR=1.43, CI 0.74 to 2.78
Baxt[30]	3	Multiple HEMS services (seven centres)	Retrospective	All blunt trauma patients	1273 HEMS	Seven HEMS services — four had physician, three had nurse or paramedic	NS	NS	NS	TRISS based analysis	Done at same time as MTOS collection for TRISS data, so no adjustment made	Mortality predischarge (time period not specified)	21% reduction in overall predicted mortality (p<0.001) OR TRISS vs HEMS=1.32 (CI 1.07 to 1.63)*
Cameron[31]	3	Melbourne, Australia	Retrospective	All trauma patients.	254 HEMS	HEMS — paramedic	HEMS — 14% (58% of patients with GCS<8 intubated)	HEMS — 32 min	HEMS — 19 min/ 28 miles	TRISS based analysis	Only one group, so no need for control	Mortality (time not specified)	Predicted mortality 17%, actual mortality 14% (p>0.05) OR TRISS vs HEMS1.13 (95% CI 0.70 to 1.82)*
Jacobs[32]	3	Connecticut, USA	Retrospective	All trauma patients. Scene trauma patients analysed as a subgroup	3620 HEMS	HEMS — nurse or paramedic	NS	NS	NS	TRISS based analysis	Nil	Mortality predischarge (time frame not specified)	13% reduction from predicted mortality with HEMS (p=0.004). If TS between 4 and 13 then 35% reduction in mortality OR TRISS vs HEMS=1.21 (CI 1.09 to 1.34)*
Younge[33]	2	London, England	Prospective	Blunt trauma patients	632 HEMS	NS	NS	NS	NS	TRISS based analysis (UK MTOS as control group)	Low M stat (0.61) led authors to calculate an adjusted W stat	Additional survivors (time frame not specified)	W statistic=4.16 ±2.21 with HEMS (p value not specified)
Comparison of HEMS and GMT using TRISS-based analysis													

Continued

Table 1 Continued

Author	Grade of evidence	Study population	Study design	Inclusion criteria	Sample size	Staffing	Intubation rate	Time at scene (min)	Time and/or distance of transfer	Analysis	Adjustments	Outcomes	Findings
Baxt[34]	3	University of California, San Diego	Retrospective	All blunt trauma patients	150 HEMS 150 GMT	HEMS — physician GMT — EMT or paramedic	NS GMT staff only trained to use oesophageal obturator airway	NS	HEMS — 24 min (136 cases in rural setting) GMT — 10 min (16 cases in rural setting)	TRISS based analysis	No further adjustments. Showed age, mechanism of injury and incidence of head injury were not statistically different	Mortality predischarge (time period not specified)	52% reduction in TRISS predicted mortality with HEMS (21 predicted deaths, 10 actual deaths, $p<0.001$), no change with GMT (15 predicted deaths, 19 actual deaths, $p>0.05$) OR GMT vs HEMS=3.07 (CI 1.43 to 6.60)*
Biewener[35]	3	Dresden, Germany	Retrospective	Blunt trauma (ISS 16–67), alive on arrival to hospital, <75 years of age	140 HEMS 70 GMT	HEMS — physician GMT — physician	HEMS — 91% GMT — 75%	See right	Accident to arrival at ED: HEMS — 90 min GMT — 68 min	TRISS based analysis	Adjustment for time from incident to arrival at ED. Both had physicians onboard	30 day mortality	Adjusted OR GMT vs HEMS=1.06 (CI 0.43 to 2.64)
Buntman[36]	3	Johannesburg, South Africa	Retrospective	Trauma patients. Not clearly specified, but states it excluded 'minor injuries'. Patients excluded if dead on arrival to trauma unit.	122 HEMS 306 GMT (BLS)	HEMS — NS GMT — any road transport to hospital, including civilian transport	NS	NS	NS	TRISS based analysis (used USA MTOS data)	Nil — TRISS study	Mortality predischarge (time not specified)	21.4% reduction in mortality with HEMS, $p<0.05$ (HEMS predicted 38.15 deaths, 39 actual deaths/ GMT predicted 38.96 deaths, 51 actual deaths). OR GMT vs HEMS 1.47 (95% CI 0.94 to 2.29)* (M stat=0.618 HEMS, 0.867 ground)
Phillips[37]	3	San Antonio, USA (Brookes Army Medical Center)	Retrospective	All trauma patients, paediatric and adult	105 HEMS 687 GMT	HEMS — nurse and paramedic GMT — paramedic	NS. Both intubation capable	NS	HEMS — 24 min GMT — 14 min	TRISS based analysis	Nil	Mortality (time frame not specified)	GMT predicted=39.11, actual=41 deaths HEMS predicted=16.44, actual=15 p value not specified OR GMT vs HEMS 1.14 (CI 0.64 to 2.05)*

Continued

Table 1 Continued

Author	Grade of evidence	Study population	Study design	Inclusion criteria	Sample size	Staffing	Intubation rate	Time at scene (min)	Time and/or distance of transfer	Analysis	Adjustments	Outcomes	Findings
Schwartz[38]	3	Connecticut, USA	Retrospective	Blunt trauma patients	93 HEMS 33 GMT	HEMS—physician GMT—Paramedic	HEMS—42% GMT—3%	HEMS — 22 min GMT — 19 min	HEMS — 10 min GMT — 11 min	TRISS based analysis	Nil	Mortality (time frame not specified)	HEMS=2.23 SD better than national norm GMT=−2.69 SD worse than national norm Significant difference
Schwartz[39]	3	Connecticut, USA	Retrospective	Blunt trauma patients	68 HEMS 605 GMT	NS	NS	NS	NS	TRISS based analysis	Insufficient subgroup data to adjust mortality	Mortality predischarge (time frame not specified)	HEMS predicted mortality=19.7%, actual 14.8% GMT predicted mortality=2.7%, actual=3.8% (p value not specified) OR GMT vs HEMS=2.44 (CI 1.22 to 4.88)*
Adjusted mortality comparison of HEMS and GMT													
Braithwaite[40]	3	Pennsylvania, USA	Retrospective	All trauma patients — split into five categories	15938 HEMS 6473 GMT (ALS capable)	NS	NS	NS	NS	Adjusted mortality comparison	Controlled for age, sex, ISS, RTS hypotension, rural urban status	Survival	Five ISS categories: 1. ISS 1–15 — no significant difference in survival 2. ISS 16–30 — HEMS 2.1 times more likely to survive ($p<0.05$) 3. ISS 31–45 — HEMS 2.4 times more likely to survive ($p<0.05$) 4. ISS 46–60 — HEMS 2.6 times more likely to survive ($p<0.05$) 5. ISS 61–75 — no significant difference in survival
Davis[41]	3	California, USA	Retrospective	Trauma patients with head AIS≥3	3017 HEMS 7295 GMT	HEMS — nurse + physician, nurse or paramedic GMT — paramedic	HEMS — 41% GMT — 14%	NS	NS	Adjusted mortality comparison	Age, sex, ISS, head AIS, injury mechanism, prehospital GCS, hypotension	Mortality (time frame not specified)	Adjusted OR GMT vs HEMS 1.9 (CI 1.6 to 2.25)

Continued

Table 1 Continued

Author	Grade of evidence	Study population	Study design	Inclusion criteria	Sample size	Staffing	Intubation rate	Time at scene (min)	Time and/or distance of transfer	Analysis	Adjustments	Outcomes	Findings
Frankema[42]	2	Rotterdam, Netherlands	Prospective	All trauma patients with ISS>15. Excluded if dead on arrival at scene, age<15, injuries invariably fatal (AIS-90 code 6)	107 attended by HEMS 239 attended solely by GMT	HEMS — physician GMT — paramedic	NS. Both intubation capable	HEMS — 31 min GMT — 23 min	HEMS — 13 min (by road) GMT — 13 min	Adjusted mortality comparison	Age, trauma mechanism, ISS score, vital scores, time of day	90 day survival	Overall adjusted survival OR HEMS vs GMT=2.2 (CI 0.92 to 5.9) Blunt trauma survival OR=2.8 (CI 1.07 to 7.52)
Oppe[43]	2	Rotterdam, Netherlands	Prospective	All trauma patients. Excluded patients dead before arrival at hospital	210 attended by HEMS 307 attended solely by GMT	NS	NS	NS	NS	Adjusted mortality comparison	Adjusted for RTS and ISS	Mortality (time-frame not specified)	Maximum mortality reduction of 17% with HEMS (extensive statistical analysis)
Ringburg[44]	3	Netherlands	Not specified	All trauma patients ≥15years	260 HEMS assistance (no patients trans-ported to hospital by HEMS) 1197 GMT	HEMS — physician GMT — paramedic	NS (GMT team not intubation capable)	HEMS — 35.4 min GMT — 24.6 min	NS	Adjusted mortality comparison	Adjusted for on-scene RTS, ISS, age, mechanism of trauma, day/night time	Mortality within 1 month	Adjusted OR GMT vs HEMS=1.0 (95% CI 0.8 to 1.3)
Thomas[45]	3	Massachusetts, USA	Retrospective	Blunt trauma patients	1150 HEMS 10106 GMT	HEMS—physician or nurse GMT—Paramedic	NS. All HEMS intubation capable, 90% ground intubation capable	NS	NS	Adjusted mortality comparison	Controlled for age, ISS, prehospital level of care, receiving trauma centre	Mortality predischarge (time frame not specified)	OR GMT vs HEMS =1.61 (CI 2.22 to 1.16)
Direct mortality comparison of HEMS and GMT													
Baxt[46]	3	California	Retrospective	Blunt head injury (GCS≤8)	104 HEMS 128 GMT	HEMS — physician GMT — Paramedic or EMT	HEMS — 100% GMT — oesophageal airway only	HEMS — 17 min GMT — 10 min	HEMS — 15 min GMT — 6 min	Direct mortality comparison	Showed no significant difference in GCS distribution, need for neurosurgery, or pathology	6 month mortality rate	40% GMT mortality 31% HEMS mortality (p<0.001) OR ground vs HEMS=1.49 (CI 0.86 to 2.57) *
Celli[47]	3	Italy	Retrospective	Blunt trauma head injury patients (GCS<8, but not brain dead and in coma for >6 h after admission)	20 HEMS 24 GMT	HEMS — nurse ± physician (distribution not stated) GMT—paramedic, police, firefighter or private	HEMS — 80% GMT — 10%	NS	NS	Direct mortality comparison	Showed no significant difference in age, GCS or associated injuries	6 month mortality	HEMS mortality=20% GMT mortality=54% (p=0.02) OR GMT vs HEMS 4.73 (95% CI 1.22 to 18.39) *

Continued

Table 1 Continued

Author	Grade of evidence	Study population	Study design	Inclusion criteria	Sample size	Staffing	Intubation rate	Time at scene (min)	Time and/or distance of transfer	Analysis	Adjustments	Outcomes	Findings
Cunningham[48]	3	North Carolina, USA	Retrospective	All trauma patients.	1346 HEMS 17144 GMT	NS	NS	HEMS — 24 min GMT — 13 min	HEMS — 33 min GMT — 17 min	Direct mortality comparison and adjusted comparison	ISS, trauma score, mortality RR, age, length of transfer	Mortality predischarge (time period not specified)	Overall non-significant improved survival in HEMS group. If ISS 21–30 and TS 5–8 then HEMS mortality 43.4%, GMT mortality 62.6% ($p<0.05$) If TS 9–12 then HEMS mortality 20%, GMT mortality 37.2% ($p<0.05$)
Di Bartolomeo[49]	2	Italy (North East)	Prospective	Blunt trauma cardiac arrest and ISS≥16	56 HEMS 73 GMT	HEMS — physician GMT — nurse	NS	NS	NS	Direct mortality comparison	Showed groups were similar for injury mechanism, gender and time to CPR, but did not allow for age differences, time to hospital and performance of on-scene CPR	Survival to discharge (time frame not specified)	3.6% survival with HEMS, 0% survival with GMT (not significant). Also showed 16% ROSC in HEMS, 1% in GMT
Nardi[50]	2	Italy (North East)	Prospective	Involuntary blunt trauma, ISS>15	42 HEMS 98 GMT(BLS)	HEMS — physician GMT — EMT, nine had non-intubation capable physician	HEMS – 81% GMT – 0%	NS	Time from dispatch to admission: HEMS — 55 min GMT — no physician 27 mins, physician 34 mins	Direct mortality comparison	Groups were statistically similar with regard to age, sex and mean ISS, so no adjustments made	Mortality to discharge from ICU (time frame not specified)	HEMS mortality=12% GMT mortality = 32% ($p<0.05$) OR GMT vs HEMS=3.42 (95% CI 1.23 to 9.56)*
Schiller[51]	3	Arizona, USA	Retrospective	Blunt trauma patients with ISS 20–40	347 HEMS 259 GMT	HEMS — paramedic GMT — paramedic	NS	NS	HEMS — 53 min in city, 48 min outside city GMT — 37 min in city, 59 min outside city 92% ground patients from within city, 30% HEMS from within city	Direct mortality comparison	Reported mean TS (HEMS 12.1, GMT 12.7), mean GCS (HEMS 9.6, GMT 10.4), age, days of hospitalisation and gender statistically similar	Mortality (time frame not specified)	18% HEMS mortality 13% GMT mortality (p value not specified) GMT vs HEMS OR=0.68 (95% CI 0.43 to 1.07)*

*Indicates OR calculated by authors of this paper.
AIS, Abbreviated Injury Score; ALS, advanced life support; BLS, basic life support; ED, emergency department; EMT, emergency medical technician; GCS, Glasgow Coma Scale; GMT, ground medical transport; HEMS, helicopter emergency medical service; ISS, Injury Severity Score; NS, not specified; ROSC, return of spontaneous circulation; (R) TS, (Revised) Trauma Score; TRISS, Trauma Score–Injury Severity Score (a score used to predict probability of survival).
W statistic=excess number of survivors per 100 when compared with patients from Major Trauma Outcome Study (MTOS).
M statistic represents the degree of similarity between the sample group and patients from the MTOS (1.00=identical patient group).

35% lower than that predicted by the trauma score–injury severity score (TRISS) method, whereas the nurse-staffed HEMS crew had a mortality rate that was the same as that predicted. This difference in mortality was significant. Similar results were shown in a retrospective cohort study.[24] Other work,[25] a retrospective, consecutive observational cohort study of a change in practice, has, however, contradicted this; the two crews were compared 2 years apart.

The aforementioned studies all focus on the effect that the presence of a physician on a HEMS has on mortality. There is, however, a core debate as to the benefit of a physician at the injury scene irrespective of the transfer mode. Work by Liberman *et al*[53] compared three groups of trauma patients, all of whom were injured in an urban setting and transported by GMT to a level 1 trauma centre. Group 1 received physician-provided advanced life support (ALS), group 2 paramedic-provided ALS and group 3 emergency medical technician (EMT)-provided basic life support (BLS). The results showed that those receiving physician-provided ALS had the highest mortality rate and those receiving EMT-provided BLS the lowest (group 1 23%, group 2 20%, group 3 19%). There was, however, a significantly higher mean Injury Severity Score (ISS) and on-scene time in the physician group. No attempt was made to control for this difference in mean ISS, but in patients with severe but survivable injuries (ISS 25–49) there was still a significantly higher mortality rate in the physician group. It must be emphasised that the work by Liberman *et al* was within an urban setting and earlier work by Messick *et al* in 1990 showed that ALS training for paramedics attending trauma patients in a rural setting provided a significant improvement in mortality.[54] Such a difference in outcome may be influenced by the longer distances to the scene of injury as well as to the receiving trauma unit. The literature[25 53] may therefore suggest that ALS, particularly that provided by physicians, serves no additional benefit in urban settings. The fact that this contradicts the evidence for the effect of a physician on trauma patient mortality with helicopter-supported EMS is of interest. This may be a result of the, in general, greater prehospital times reported with a HEMS service and the services often being deployed over larger distances. The higher skill base and clinical decision-making of a physician may then confer more benefit and become significant.

The effectiveness of GMT in an urban environment should be taken into consideration when a HEMS service is being evaluated in that setting. Work by Nicholl *et al* in 1995[14] in the UK focused on the mortality outcomes associated with the use of the London HEMS, representative of an urban setting. This study compared a physician-staffed HEMS with a paramedic-staffed GMT service transporting to 20 hospitals, one of which was equivalent to a level 1 trauma centre. Patients in the HEMS group were all attended by physician-staffed HEMS and transported to hospital either by helicopter, by GMT with a physician in attendance, or by GMT with no-one from HEMS in attendance. The authors compared actual mortality rates with those predicted by TRISS and found that HEMS had a 15.6% increase in mortality from predicted and the GMT service had a 2.4% increase from predicted. After adjusting for the nature and severity of injuries, Nicholl *et al* found no difference in survival in the cohorts. The M-statistic (a measure of the similarity of injury severity mix to the prediction database eg, MTOS[55]) was, however, not specified, and it should be noted that a 4-year study performed by Younge *et al*,[33] 2 years of which included the same patient population used by Nicholl *et al*, found an M-statistic of 0.61, which was below the acceptable value of 0.88. The study by Younge *et al* found an adjusted W statistic (adjustment for a patient caseload of high injury severity) of 4.16±2.21, meaning that between two and six extra trauma patients in every 100 transported by HEMS rather than GMT survive. Younge included only patients transported by HEMS to a major trauma centre, unlike Nicholl *et al*, who included all patients transported to 19 other hospitals. The results from the study performed by Nicholl *et al* should be interpreted with both interest and caution. It questions the effectiveness of HEMS within an urban setting, but what must be considered is the trauma system in which the study was performed. HEMS patients could be transported from the scene in three different ways to 20 different receiving hospitals, only one of which was a major trauma centre. This is in contrast to many of the studies included in this review (including that by Younge *et al*[33]), which compare HEMS and GMT transporting to the same major trauma centre. A potential benefit of HEMS is the ability to transfer patients directly from the scene to the most appropriate definitive treatment facility and, therefore, when studying the effect of HEMS on trauma patient mortality, the treatment facility should be considered as part of the service. This was suggested, but not proven, by Nicholls for only the most severely injured.

The question of whether HEMS confers a mortality benefit by being able to transport a physician to the scene of injury is one with no clear answer. Multiple other factors need to be considered, including the most appropriate way to deliver the physician to the scene (GMT vs HEMS) and the proximity to the receiving trauma centre.

Transport of advanced airway skills to the scene

An important distinction must be drawn between the presence of a physician and the ability to manage an airway to a high standard (ie, intubation and ventilation management capable). They are neither mutually inclusive nor exclusive. Head injury is known to be an important predictor of mortality in trauma cases[56] and a procedure known to be of great benefit in the management of these patients is that of endotracheal intubation (ETI). A study by Davis *et al* in 2005[41] showed that prehospital ETI as opposed to emergency department intubation in HEMS-transported patients with severe head injuries improved outcome significantly (OR 1.4, 95% CI 1.1 to 1.8).

Helicopter EMS allow a small number of highly skilled and experienced healthcare professionals, trained in ETI, to reach a large number of trauma patients over a wide area.

Transporting a team experienced in managing trauma patients

HEMS allow an experienced trauma team to cover a far greater distance than would be possible by GMT. This has the benefit of allowing a healthcare team to increase their experience and proficiency in managing trauma patients by caring for such patients on a daily basis. The resources to train multiple ground crews to the same level of expertise would be great and might not be cost-effective.[57]

The way in which an experienced team is delivered to the scene is open to debate. Since 1995, the Netherlands has changed its approach to prehospital care. Helicopter-transported medical teams (HMT), consisting of specially trained trauma physicians and paramedics, attend the scene of injury to provide an additional therapeutic option to that available with the GMT team alone, but the helicopter only rarely transports the patient to hospital.[42] Factors that contributed to that policy include the disadvantages of noise, disorientation and limited space when using helicopters for patient transfer.

There are three studies included in this systematic review that compare the outcome of trauma patients in the Netherlands who are attended to by HEMS and those who are not. Two of these demonstrated a mortality benefit with HMT attendance[42 43] and the third showed no significant difference.[44] These data suggest that an improvement in outcome in those attended by HEMS is more a result of the presence of an experienced trauma team than the transport method. Such a system could be considered in other countries with similar geography, such as the UK.

To expedite transport of patients from the scene to hospital

Although a helicopter service is often suggested as being able to expedite the transport of patients to the appropriate facility, the data often do not support such a hypothesis. Of the studies included in this review that record the time at the scene and duration of transfer, the majority show that both are increased with helicopter EMS. It must be remembered, however, that this does not account for distance of transfer — a factor that may be greater in the HEMS group as a result of both tasking to remote locations and a preference for bypassing local hospitals to access definitive care in a major trauma centre. A study by Ringburg *et al* in 2007[44] focused on the impact that HEMS attendance to trauma patients had on overall on-scene times (OST) and subsequent mortality. HEMS patients had significantly longer mean OST than the group only attended by the GMT team (34 vs 24 min), but no mortality difference was seen after controlling for multiple patient and trauma characteristics. The authors concluded that HEMS does lead to an increase in OST, but that this is neutralised by the increased survival brought by HEMS attendance.

A possible explanation for the prolonged prehospital time is that the presence of a physician increases the number of procedures undertaken at the scene. That study by Ringburg *et al*[44] compared a physician-staffed helicopter EMS and a paramedic-staffed GMT team. Interestingly, however, two recent UK-based studies[58 59] both demonstrated that the addition of doctors to a HEMS crew did not alter OST, but did increase the number of advanced medical interventions performed at the scene.

The increased prehospital time often seen with HEMS may therefore be a result of longer transfer distance, more on-scene intervention and being preferentially deployed in cases of prolonged extrication. It may also be due to logistical factors, such as delayed helicopter deployment awaiting greater clinical information, patients held on scene awaiting HEMS, identifying a suitable landing site, and moving the patient to and from the helicopter.

Triage to the definitive treatment facility

Helicopter EMS have the ability to travel greater distance than GMT in the same time. This means that patients transported by HEMS are potentially able to be taken directly to a specialist trauma facility or one where definitive care can be delivered, avoiding secondary transfers. The importance of this was demonstrated by the work of Biewener *et al* in 2004.[35] Four hundred and three trauma patients were managed in four different ways: 1. HEMS transport to a university hospital (HEMS−UNI); 2. GMT to a university hospital (GMT−UNI); 3. GMT to a regional hospital (GMT−REG); and 4. GMT to a regional hospital with subsequent transfer to a university hospital (INTER). This showed that mortality of the GMT−REG group was almost double that of the HEMS−UNI group (41.2 vs 22.1%, p=0.002). The authors also showed that there was no significant difference in mortality between the GMT−UNI and HEMS−UNI group after adjustment. The authors, therefore, concluded that the difference in mortality rate seen between the HEMS−UNI and GMT−REG group was a result of the receiving facility, not the transport method.

The degree to which either HEMS or GMT will be superior with regards to triaging patients to the correct facility will depend on accuracy of triage tools, geographical locations of incidents and hospitals, and the trauma system that functions within the region.

DISCUSSION

Reliably establishing the effect of helicopter EMS on the mortality of trauma patients transported from the scene remains challenging. The logistical and ethical barriers to a randomised controlled trial comparing HEMS with GMT in the transport of trauma patients are numerous. This has resulted in cohort studies and large registry-based studies forming the evidence base detailed above. The strategies used to assess trauma care are also limited and are ably discussed by Thomas *et al*.[45]

In recognition of these limitations of the current evidence base, careful consideration must be given to the cost-effectiveness of running an active HEMS. Work by Snooks *et al* in 1996[22] documented the cost per successful mission (a mission in which a patient was attended) in four UK-based HEMS units and found that each successful mission could cost between £404 and £1689 depending on service configuration, the crew and funding.

HEMS in the UK are currently operated by numerous private companies, many of which are funded by charitable donations. There is currently a lack of any unifying standard operating procedures and tasking protocols, clinical governance, or auditing of the helicopter EMS activity. These helicopters can usually only operate during daylight hours and have limited capability in difficult weather conditions. The UK Search and Rescue Framework published in April 2008[60] describes the integration of multiple organisations (government, military and charitable) in providing a coastal and sea emergency service with centralised management and tasking. The helicopters currently in this UK SAR service are capable of a much higher level of operation, 24 h a day in almost all weather conditions. Such a Framework will act as guide for a future UK HEMS service and may contribute to trauma network planning.

The debate over the role and structure of HEMS in a modern trauma service is likely to continue. The authors recommend that when designing regional trauma networks there should be a needs assessment for prehospital care specific to each network based on critical incident frequency and travel times. The benefits and capabilities of the emergency medical teams on scene should be considered separately from those of using helicopters or land vehicles as the transport platform; helicopters may be one of the solutions for moving the EMS or patient or both. It is likely that prehospital EMS services, operating in different trauma systems, with different terrain and geographical arrangements of hospital facilities, will come to different conclusions about the appropriate need for either or both of these resources. Such conclusions should be based on event incidence modelling and accrued outcome data, and devise a service that can deliver the required care at all times of the day and night.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

1. **National Confidential Enquiry into Patient Outcome and Death [internet].** Trauma: who cares? c2007 (accessed 23 Sep 2009). http://www.ncepod.org.uk/2007t.htm.
2. **van Beek EF,** van Roijen L, Mackenback JP. Medical costs and economic production losses due to injuries in the Netherlands. *J Trauma* 1997;**42**:1116–23.
3. **University of Oxford [internet].** Centre for evidence based medicine—Levels of Evidence; c2009 (updated 14 Sep 2009, accessed 23 Sep 2009). http://www.cebm.net/index.aspx?o=1025.
4. **Arfken CL,** Shapiro MJ, Bessey PQ, *et al*. Effectiveness of helicopter versus ground ambulance services for interfacility transport. *J Trauma* 1998;**45**:785–90.
5. **Boyd CR,** Corse KM, Campbell RC. Emergency interhospital transport of the major trauma patient: air versus ground. *J Trauma* 1989;**29**:789–93; discussion 793–4.
6. **Di Bartolomeo S,** Sanson G, Nardi G, *et al*. Effects of 2 patterns of prehospital care on the outcome of patients with severe head injury. *Arch Surg* 2001;**136**:1293–300.
7. **Iirola TT,** Laaksonen MI, Vahlberg TJ, *et al*. Effect of physician-staffed helicopter emergency medical service on blunt trauma patient survival and prehospital care. *Eur J Emerg Med* 2006;**13**:335–9.
8. **Kerr WA,** Kerns TJ, Bissell RA. Differences in mortality rates among trauma patients transported by helicopter and ambulance in Maryland. *Prehosp Disaster Med* 1999;**14**:159–64.
9. **Larson JT,** Dietrich AM, Abdessalam SF, *et al*. Effective use of the air ambulance for pediatric trauma. *J Trauma* 2004;**56**:89–93.
10. **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.
11. **Mitchell AD,** Tallon JM, Sealy B. Air versus ground transport of major trauma patients to a tertiary trauma centre: a province-wide comparison using TRISS analysis. *Can J Surg* 2007;**50**:129–33.
12. **Moront M,** Gotschall CS, Eichelberger MR. Helicopter transport of injured children: system effectiveness and triage criteria. *J Pediatr Surg* 1996;**31**:1183–6; discussion 1187–8.
13. **Moylan JA,** Fitzpatrick KT, Beyer AJ 3rd, *et al*. Factors improving survival in multisystem trauma patients. *Ann Surg* 1988;**207**:679–85.
14. **Nicholl JP,** Brazier JE, Snooks HA. Effects of London helicopter emergency medical service on survival after trauma. *BMJ* 1995;**311**:217–22.
15. **Kurola J,** Wangel M, Uusaro A, *et al*. Paramedic helicopter emergency service in rural Finland - do benefits justify the cost? *Acta Anaesthesiol Scand* 2002;**46**:779–84.
16. **Bledsoe BE,** Wesley AK, Eckstein M, *et al*. Helicopter scene transport of trauma patients with nonlife-threatening injuries: a meta-analysis. *J Trauma* 2006;**60**:1257–65; discussion 1265–6.
17. **Shatney CH,** Homan SJ, Sherck JP, *et al*. The utility of helicopter transport of trauma patients from the injury scene in an urban trauma system. *J Trauma* 2002;**53**:817–22.
18. **Brazier JE,** Nicholl JP, Snooks HA. The cost and effectiveness of the London Helicopter Emergency Medical Service. *J Health Serv Res Policy* 1996;**1**:232–7.
19. **Chappell VL,** Mileski WJ, Wolf SE, *et al*. Impact of discontinuing a hospital-based air ambulance service on trauma patient outcomes. *J Trauma* 2002;**52**:486–91.
20. **Dardis R,** Roberts G, Phillips J. A cost-benefit evaluation of helicopter transfers to the Beaumont neurosurgical unit. *Ir Med J* 2000;**93**:50–1.
21. **Macnab AJ,** Wensley DF, Sun C. Cost-benefit of trained transport teams: estimates for head-injured children. *Prehosp Emerg Care* 2001;**5**:1–5.
22. **Snooks HA,** Nicholl JP, Brazier JE, *et al*. The costs and benefits of helicopter emergency ambulance services in England and Wales. *J Public Health Med* 1996;**18**:67–77.
23. **Davis DP,** Stern J, Sise MJ, *et al*. A follow-up analysis of factors associated with head-injury mortality after paramedic rapid sequence intubation. *J Trauma* 2005;**59**:486–90.
24. **Garner A,** Rashford S, Lee A, *et al*. Addition of physicians to paramedic helicopter services decreases blunt trauma mortality. *Aust N Z J Surg* 1999;**69**:697–701.
25. **Hamann BL,** Cué JI, Miller FB, *et al*. Helicopter transport of trauma victims: does a physician make a difference? *J Trauma* 1991;**31**:490–4.
26. **McCowen CL,** Swanson ER, Thomas F, *et al*. Outcomes of blunt trauma victims transported by HEMS from rural and urban scenes. *Prehosp Emerg Care* 2007;**11**:383–8.
27. **Schmidt U,** Frame SB, Nerlich ML, *et al*. On-scene helicopter transport of patients with multiple injuries—comparison of a German and an American system. *J Trauma* 1992;**33**:548–53; discussion 553–5.
28. **Malacrida RL,** Anselmi LC, Genoni M, *et al*. Helicopter mountain rescue of patients with head injury and/or multiple injuries in southern Switzerland 1980–1990. *Injury* 1993;**24**:451–3.
29. **Bartolacci RA,** Munford BJ, Lee A, *et al*. Air medical scene response to blunt trauma: effect on early survival. *Med J Aust* 1998;**169**:612–16.
30. **Baxt WG,** Moody P, Cleveland HC, *et al*. Hospital-based rotorcraft aeromedical emergency care services and trauma mortality: a multicenter study. *Ann Emerg Med* 1985;**14**:859–64.
31. **Cameron PA,** Flett K, Kaan E, *et al*. Helicopter retrieval of primary trauma patients by a paramedic helicopter service. *Aust N Z J Surg* 1993;**63**:790–7.
32. **Jacobs LM,** Gabram SG, Sztajnkrycer MD, *et al*. Helicopter air medical transport: ten-year outcomes for trauma patients in a New England program. *Conn Med* 1999;**63**:677–82.
33. **Younge PA,** Coats TJ, Gurney D, *et al*. Interpretation of the Ws statistic: application to an integrated trauma system. *J Trauma* 1997;**43**:511–15.
34. **Baxt WG,** Moody P. The impact of a rotorcraft aeromedical emergency care service on trauma mortality. *JAMA* 1983;**249**:3047–51.
35. **Biewener A,** Aschenbrenner U, Rammelt S, *et al*. Impact of helicopter transport and hospital level on mortality of polytrauma patients. *J Trauma* 2004;**56**:94–8.
36. **Buntman AJ,** Yeomans KA. The effect of air medical transport on survival after trauma in Johannesburg, South Africa. *S Afr Med J* 2002;**92**:807–11.
37. **Phillips RT,** Conaway C, Mullarkey D, *et al*. One year's trauma mortality experience at Brooke Army Medical Center: is aeromedical transportation of trauma patients necessary? *Mil Med* 1999;**164**:361–5.
38. **Schwartz RJ,** Jacobs LM, Juda RJ. A comparison of ground paramedics and aeromedical treatment of severe blunt trauma patients. *Conn Med* 1990;**54**:660–2.
39. **Schwartz RJ,** Jacobs LM, Yaezel D. Impact of pre-trauma center care on length of stay and hospital charges. *J Trauma* 1989;**29**:1611–15.
40. **Brathwaite CE,** Rosko M, McDowell R, *et al*. A critical analysis of on-scene helicopter transport on survival in a statewide trauma system. *J Trauma* 1998;**45**:140–4; discussion 144–6.
41. **Davis DP,** Peay J, Serrano JA, *et al*. The impact of aeromedical response to patients with moderate to severe traumatic brain injury. *Ann Emerg Med* 2005;**46**:115–22.
42. **Frankema SP,** Ringburg AN, Steyerberg EW, *et al*. Beneficial effect of helicopter emergency medical services on survival of severely injured patients. *Br J Surg* 2004;**91**:1520–6.
43. **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.
44. **Ringburg AN,** Spanjersberg WR, Frankema SP, *et al*. Helicopter emergency medical services (HEMS): impact on on-scene times. *J Trauma* 2007;**63**:258–62.
45. **Thomas SH,** Harrison TH, Buras WR, *et al*. Helicopter transport and blunt trauma mortality: a multicenter trial. *J Trauma* 2002;**52**:136–45.
46. **Baxt WG,** Moody P. The impact of advanced prehospital emergency care on the mortality of severely brain-injured patients. *J Trauma* 1987;**27**:365–9.
47. **Celli P,** Fruin A, Cervoni L. Severe head trauma. Review of the factors influencing the prognosis. *Minerva Chir* 1997;**52**:1467–80.
48. **Cunningham P,** Rutledge R, Baker CC, *et al*. A comparison of the association of helicopter and ground ambulance transport with the outcome of injury in trauma patients transported from the scene. *J Trauma* 1997;**43**:940–6.
49. **Di Bartolomeo S,** Sanson G, Nardi G, *et al*. HEMS vs. Ground-BLS care in traumatic cardiac arrest. *Prehosp Emerg Care* 2005;**9**:79–84.
50. **Nardi G,** Massarutti D, Muzzi R, *et al*. Impact of emergency medical helicopter service on mortality for trauma in north-east Italy. A regional prospective audit. *Eur J Emerg Med* 1994;**1**:69–77.
51. **Schiller WR,** Knox R, Zinnecker H, *et al*. Effect of helicopter transport of trauma victims on survival in an urban trauma center. *J Trauma* 1988;**28**:1127–34.
52. **Baxt WG,** Moody P. The impact of a physician as part of the aeromedical prehospital team in patients with blunt trauma. *JAMA* 1987;**27**:365–9.
53. **Liberman M,** Mulder D, Sampalis J. Advanced or basic life support for trauma: Metaanalysis and critical review of the literature. *J Trauma* 2000;**49**:584–99.
54. **Messick J,** Rutledge R, Meyer AA. Advanced life support training is associated with decreased trauma death rates: an analysis of 12,417 trauma deaths. *J Trauma* 1990;**30**:1621.
55. **Hollis S,** Yates DW, Woodford M, *et al*. Standardized comparison of performance indicators in trauma: a new approach to case-mix variation. *J Trauma* 1995;**38**:763–6.
56. **Champion H,** Copes WS, Sacco WJ, *et al*. The major trauma outcome study: establishing national norms for trauma care. *J Trauma* 1990;**30**:1356–65.
57. **Bruhn JD,** Williams KA, Aghababian R. True cost of air medical vs ground ambulance systems. *Air Med J* 1993;**12**:262–68.
58. **Roberts K,** Blethyn K, Foreman M, *et al*. Influence of air ambulance doctors on on-scene times, clinical interventions, decision making and independent paramedic practice. *Emerg Med J* 2009;**26**:128–34.
59. **Dissmann PD,** Le Clerc S. The experience of Teeside helicopter emergency services: doctors do not prolong prehospital on-scene times. *Emerg Med J* 2007;**24**:59–62.
60. **Maritime and Coastguard Agency [internet].** Search and Rescue Framework for the United Kingdom of Great Britain and Northern Ireland, c2008. http://www.mcga.gov.uk/c4mca/uksar.pdf (accessed 23 Sep 2009).