Critical care paramedics: where is the evidence? a systematic review

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ABSTRACT

Objectives Paramedic-delivered prehospital critical care is an established concept in a number of emergency medical services around the world and, more recently, has been introduced to the UK. This review identifies and describes the available evidence relating to paramedics who routinely provide prehospital critical care as primary scene response (critical care paramedics, or CCP).

Methods A systematic search of electronic databases was performed: CENTRAL, EMBASE, MEDLINE (through EMBASE and Web of Knowledge) and Web of Science (through Web of Knowledge).

Results The search identified 12 relevant publications, one of which was a randomised controlled trial. The remaining 11 were retrospective studies. Five studies compared CCPs with physician-led care. Three of these publications demonstrated improved outcomes with physician care, while two showed no difference. Four further publications examined CCPs versus non-physician-led care and found improved outcomes (two studies), mixed effects (one study) and no difference (one study) for CCPs. Finally, three publications addressed the addition of skills to CCP competencies. A randomised controlled trial of CCP rapid sequence induction (RSI) and tracheal intubation demonstrated improved neurologic outcomes. CCP tube thoracostomy was shown to have similar complication rates to the same procedure performed in the emergency department, while addition of a non-invasive ventilation protocol to CCP practice had no effect on long-term mortality.

Conclusions There is limited evidence to support the concept of paramedic-delivered prehospital critical care. The best available evidence suggests a benefit from prehospital RSI carried out by CCPs in patients with severe traumatic brain injury, but the impact of CCPs remains unclear for many conditions. Further high-quality research in this area would be welcome.

INTRODUCTION

The UK has seen a steady increase in emergency ambulance calls over the past decade, with the call volumes approaching 8 million in 2009–2010.1 Only a small proportion of these incidents require prehospital critical care interventions, such as advanced airway management, cardiopulmonary resuscitation or inotropic support.2 The average prehospital provider is, therefore, only rarely able to carry out such interventions3 which are often complex and carry the risk of serious complications.4 This leaves emergency medical services (EMS) and prehospital providers faced with the challenge of how to provide appropriate yet efficient care for the few severely ill or injured patients in urgent need of prehospital critical care.5 The merit of advanced or critical care skills in prehospital care has been debated,6 but there is evidence that extended procedural capacity and decision making benefits many patient groups.7 8

The question of who should be providing prehospital critical care is an ongoing controversy.9 10 Concerns regarding the risk of detrimental effects have led to the conclusion that only physicians should undertake certain interventions, such as rapid sequence induction (RSI) of anaesthesia and tracheal intubation.4 11 12 Others would argue that it is not the professional group of theprehospital provider that determines capability but clinical competency, and therefore, well trained and experienced paramedics should be able to provide an equivalent level of prehospital critical care to physicians.13 14 Paramedics subspecialising in the delivery of prehospital critical care have become established in North America, mainly as flight paramedics on helicopters, providing interhospital transfers and/or primary scene responses.15 In parts of Australia, mobile intensive care ambulance (MICA) paramedics are dispatched to patients with suspected major trauma, either by car or helicopter.14 Similar models exist in South Africa and New Zealand, and efforts to improve prehospital critical care in the UK have resulted in an increasing number of critical care paramedics (UK-CCPs) over recent years.16 UK-CCPs work either with prehospital doctors, other UK-CCPs, paramedics or on their own (author’s unpublished data, 2012). While there is no national training programme or curriculum for UK-CCPs, most UK-CCPs have additional competencies beyond that of UK paramedics, such as procedural sedation, joint or fracture reduction, and invasive interventions such as thoracostomy (authors’ unpublished data, 2012). By contrast with some of their colleagues in Australia14 or North America,15 UK-CCPs are currently not able to undertake RSI independently.12 Within the authors’ institution (South Western Ambulance Service), UK-CCPs are dispatched to severely ill or injured patients only, either by helicopter or car, and regular participation in clinical governance measures is mandatory.17

This review identifies and describes the available evidence relating to paramedics who routinely provide prehospital critical care as a primary scene response. For the purpose of clarity, we refer to paramedics acting in this capacity as ‘CCPs’, since their titles and scope of practice vary widely across different emergency medical systems.

METHODS

Literature retrieval

We performed a systematic search of electronic databases: CENTRAL, EMBASE, MEDLINE (through...
EMBASE and Web of Knowledge (through Web of Knowledge). No language limitation was applied. Due to significant developments in the practice of prehospital care, such as RSI and the use of pulse oximetry in the early 1990s, we decided to exclude papers published before 1990. This restriction was not applied to hand searches of citations in relevant reviews and manuscripts of potential interest. The searches aimed to include the general concept of paramedic-delivered critical care as well as specific critical care competencies. The fact that many CGPs work on helicopters (Helicopter Emergency Medical Services: HEMS) or fixed-wing aircrafts is also reflected in the search terms (see table 1).

**Selection of eligible studies**

Two independent reviewers (JvV-F and JW) scanned all titles followed by all abstracts of potentially relevant manuscripts. Each reviewer applied inclusion criteria to the abstract, as outlined in the box below. Full manuscripts were retrieved if inclusion criteria were met, inclusion or exclusion could not be determined with certainty or if the reviewers disagreed. The same process was repeated for the full manuscripts, except reviewer disagreement at this stage was resolved by reference to a senior reviewer (JB). One reviewer (JvV-F) then read all eligible publications in detail and discussed the findings with the senior reviewer (JB). The strength of evidence presented by

| Table 1 | Search history (completed 22 January 2013, years 1990–2013) |
|---------|----------------------------------------------------------|
| Central |                                                          |
| Paramedic* | 221 results                                        |
| Web of Knowledge (1990–2012) |                                      |
| Topic=(prehospital OR pre-hospital) | 583 results                                        |
| AND Topic=(critical care) |                                                     |
| Topic=(critical care paramedic*) | 208 results                                        |
| Topic=(mobile intensive care ambulance paramedic*) | 14 results                                        |
| Topic=(mobile intensive care ambulance service) | 71 results                                        |
| Topic=(advanced paramedic*) | 9 results                                          |
| Topic=(flight OR HEMS OR helicopter OR air ambulance) | 4 results                                          |
| AND Topic=(paramedic*) | 201 results                                        |
| Topic=(paramedic*) | 94 results                                          |
| AND Topic=(“rapid sequence induction ‘OR’ rapid sequence intubation’ OR RSI) | |
| Topic=(paramedic*) AND | 35 results                                          |
| Topic=(cricothyroidotomy OR cricoidotomy OR cricothyrotomy OR ‘surgical airway’) | |
| Topic=(paramedic*) | 77 results                                          |
| AND Topic=(“non invasive ventilation’ OR niv OR ‘non-invasive ventilation’) | 12 results                                          |
| Topic=(paramedic*) | 16 results                                          |
| AND Topic=(“chest drain’ OR thoracostomy) | 17 results                                          |
| Topic=(paramedic*) | 8 results                                           |
| AND Topic=(“thoracotomy) |                                                        |
| Topic=(paramedic*) | 300 results                                         |
| AND Topic=(“procedural sedation’ OR ‘sedation’) | 28 results                                          |
| EMBASE (1990 to 2012) |                                          |
| critical AND care AND paramedics | 288 results                                         |
| advanced AND paramedics | 371 results                                         |
| mobile AND intensive AND care AND (‘ambulance’/exp OR ambulance) | 163 results                                         |
| AND ‘knowledge/exp OR knowledge OR competencies | 269 results                                         |
| AND ‘critical care/exp OR ‘critical care’ AND ‘prehospital’ OR prehospital | |
| “rapid sequence intubation ‘OR’ rapid sequence induction” | 85 results                                         |
| AND “paramedic OR paramedical AND (‘personnel’/exp OR personnel)” | |
| “cricothyroidotomy ‘OR’ cricothyrotomy” | 80 results                                         |
| AND “paramedic OR paramedical AND (‘personnel’/exp OR personnel)” | |
| “non invasive ventilation’/exp OR ‘non invasive ventilation’” | 93 results                                         |
| AND ‘paramedic OR paramedical AND (‘personnel’/exp OR personnel)” | |
| “chest drain’/exp OR ‘chest drain’ OR ‘thoracostomy’/exp OR ‘thoracostomy’” | |
| AND “paramedic OR paramedical AND (‘personnel’/exp OR personnel)” | 77 results                                         |
| “thoracotomy’/exp OR thoracotomy” |                                                        |
| AND “paramedic OR paramedical AND (‘personnel’/exp OR personnel)” | 75 results                                         |
| “inotrope OR ‘inotropic support’ OR ‘vasopressor’/exp OR vasopressor” | |
| AND “paramedic OR paramedical AND (‘personnel’/exp OR personnel)” | 93 results                                         |
| “‘procedural sedation’ OR ‘conscious sedation’/exp OR ‘conscious sedation’” | |
| AND “paramedic OR paramedical AND (‘personnel’/exp OR personnel)” | 300 results                                         |

HEMS, Helicopter emergency medical services; RSI, rapid sequence induction.
each manuscript was assessed using the Oxford Centre of Evidence Based Medicine guidelines. Data regarding quality of description of prehospital provider competencies, intervention studied, risks of bias and study outcomes were extracted.

Presentation of results
All eligible studies are presented in a comprehensive results table. Due to the anticipated paucity of high-level evidence from randomised trials we planned a narrative analysis.

RESULTS
The search identified 3871 titles of which 609 where potentially relevant. A review of the abstracts identified 122 manuscripts for possible inclusion. This was reduced to 49 after duplications were removed. All 49 manuscripts were retrieved for further assessment.

After review of the full text publications, 12 eligible papers remained (see table 2). Reasons for exclusion of the other 37 publications were investigation of non-paramedic prehospital providers (16/37), or paramedics not working in a critical care capacity (7/37), study designs such as editorials, reviews, case series or descriptive studies without a comparative element (9/37), no reporting of clinical outcomes (4/37) and investigation of interhospital transfers only (1/37). One article did not define early or late mortality and morbidity, length of stay or complications.

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Included publications
There was one randomised, controlled trial (level II evidence). The remaining 11 studies were of level III evidence, 10 of which were retrospective cohort studies and one a quasi-randomised cohort study which did not specify whether it was prospective or retrospective. Five studies compared CCP-staffed HEMS with physician-staffed HEMS. Outcomes for HEMS CCPs compared to HEMS paramedics with basic competencies were reported in one publication, while one study compared CCP/nurse HEMS with nurse/nurse HEMS. Two further publications compared HEMS paramedics with ground paramedics. Finally, three studies examined the effects of CCPs delivering specific interventions, such as tube thoracostomy, non-invasive ventilation and RSI. The most commonly represented countries (5/12) were the USA, Canada and Australia (3/12). One study each originated from Sweden, Canada and Afghanistan. One paper compared data from the USA and Germany.

EVIDENCE REVIEW
The articles identified by this systematic search can be arranged into three distinct questions. How does CCP-led care compare to physician-led care? How does CCP-led care compare to other non-physician-led care? What is the effect of adding specific skills to existing CCP competencies?

CCPs versus physician-led care
Five studies addressed this question, of which three showed a mortality benefit for physician-staffed HEMS and two showed no difference. Physicians were at least senior residents, or faculty-level, in four of the studies, and the fifth study did not specify the level of training of the emergency physicians. Baxt and Moody found significantly improved mortality for a nurse/physician HEMS crew compared to a nurse/CCP HEMS crew. The paramedic crewmember in the CCP group had less procedural capacity compared to the HEMS nurses and physicians, and interventions were undertaken more often or more aggressively in the physician group. Garner et al compared a dual CCP HEMS crew and a physician/paramedic HEMS crew in Australia and showed improved survival of the physician group over the CCP group. This study also found significantly more interventions delivered in the physician group, including the administration of blood products and neuromuscular-blocking drugs, both of which were outside the paramedic scope of practice. Schmidt et al compared paramedic-staffed HEMS in USA with physician-staffed HEMS in Germany and found significantly more interventions delivered and less early deaths in the German group. Further differences were the absence of penetrating trauma and significantly shorter response times in the one-tier German EMS system.

Hamman’s before-and-after study included CCPs with at least 2 years of critical care experience and also an unspecified number of nurse/nurse HEMS crew missions in the non-physician group. This study found significantly improved survival for both groups compared with the Major Trauma Outcome Study (MTOS) population. There was no difference between the physician and non-physician group. Finally, Cameron et al compared staffing and dispatch of an Australian HEMS by either physicians or intensive care paramedics. While there was a significantly higher rate of discharges from the receiving emergency department (ED) during the time when CCPs were responsible for HEMS dispatch, revised trauma score, mortality, length of stay and rate of secondary transfers from the receiving hospital to another facility remained the same.

CCPs versus non-physician-led care
Of the four studies addressing this question, one compared CCP HEMS crews with paramedic HEMS crews and found a significantly better survival rate for CCP HEMS. Two publications compared CCP HEMS crews with ground paramedics, with one showing improvement in mortality in the CCP group and the other reporting mixed results. The last study compared CCP/nurse HEMS crews and nurse/nurse HEMS crews and found no difference in outcome. Mabry’s publication compared two different military HEMS crew configurations: a dual CCP crew...
| Author; country; study period | Grade of evidence; study design | Rural or urban | Inclusion criteria | CCP characteristics | Intervention | Comparison | Analysis | Adjustments | Outcomes | Findings |
|-------------------------------|--------------------------------|---------------|-------------------|---------------------|--------------|------------|---------|-------------|----------|---------|
| Baxt W; California, USA; Study period not specified | 3 Cohort, not specified if prospective or retrospective | Not specified | All blunt trauma patients receiving interventions by one of two HEMS crews and transport to one trauma centre. | HEMS nurse/paramedic crew. Nurse able to perform same procedures as physicians; paramedics restricted to non-RSI intubation, limited medication and IV access. | Nurse/paramedic HEMS crew (n=258) | Physician HEMS crew (faculty-level emergency physician) (n=316) | TRISS-based analysis | No further adjustment | Mortality (time not specified) | Mortality in nurse/paramedic group no different from predicted (Z +0.208) but better than predicted in physician group (Z +2.284). Difference in predicted and observed mortality significantly different between groups (p<0.05), favouring physician-led care. |
| Garner A; New South Wales, Australia; 1996–1998 | 3 Retrospective cohort | Mixed | All blunt trauma with ISS ≥10 transported by one of two HEMS to different receiving hospitals. | HEMS double paramedic crew. Competencies not specified, but do not include RSI or administration of blood products. | Paramedic HEMS crew (n=140) | Physician HEMS crew (faculty-level emergency physician) (n=67) | TRISS-based analysis | Adjusted W used, as M statistic indicated poor matches with MTOS patient cohort | Mortality predischarge (time not specified), Interventions delivered | Mortality less in physician group (8–19 additional survivors per 100 patients). Physicians performed more procedures than paramedics (intubation 34/67 vs 14/140, thoracostomy 8/67 vs 2/140, median volume of IV fluid in hypotensive patients 5035 mL vs 1475 mL). |
| Schmidt U; Germany/USA; 1988–1989 | 3 Retrospective cohort | Not specified | All trauma patients with multiple injuries in an American (USA) and a German (GER) HEMS, transporting to one respective trauma centre. | USA HEMS double paramedic/nurse crew. Competencies not specified. | USA paramedic HEMS crew (n=186) | GER physician HEMS crew (senior resident or faculty-level trauma surgeon) (n=221) | Direct comparison TRISS-based analysis | No further adjustment | Frequency of interventions. Early mortality (<6 h, Mortality time not specified) | More interventions (intubation, intravenous fluid, thoracostomy) in GER. More early deaths in USA than GER (12 and 4, respectively). Overall mortality in GER significantly better than predicted (Z +2.459), USA not different from predicted (Z +1.049). 10.8% penetrating trauma in USA, 0% in Germany. |
| Hamman B; Kentucky, USA; 1985–1987 | 3 Retrospective cohort | Not specified | All trauma patients transported by one HEMS before and after removal of physicians from the service. | HEMS double crew of nurse/nurse or nurse/paramedic with at least 2 years critical care experience. Same procedures as physician except cricothyrotomy and tube thoracostomy. | Non-physician HEMS crew (n=114) | Physician HEMS crew (senior resident or faculty-level emergency physician) (n=142) | TRISS-based analysis | No further adjustment | Mortality (time not specified), Interventions delivered RTS | Significantly better survival than expected for both groups (Z score +3.11 and +2.03 for the non-physician and physician group, respectively). No significant differences between the groups in trauma severity (RTS) or number and types of interventions performed. |
| Author; country; study period | Grade of evidence; study design | Rural or urban | Inclusion criteria | CCP characteristics | Intervention | Comparison | Analysis | Adjustments | Outcomes | Findings |
|-------------------------------|--------------------------------|---------------|-------------------|---------------------|--------------|------------|----------|------------|---------|----------|
| Cameron S; Queensland, Australia; 1999–2003 | 3 Retrospective cohort | Rural | All patients transported by one HEMS before and after removal of physicians from the service. | HEMS double crew of intensive care paramedics. Not able to perform RSI or invasive monitoring. | Paramedic tasking and staffing of HEMS (n=163) | Physician tasking and staffing of HEMS (emergency physician) (n=211) | Direct comparison | RTS calculated for trauma patients | Mortality at 30 days | No difference in 30-day mortality (2.8% and 2.5%), hospital length of stay (mean of 2 and 1 days) or secondary transfers (9% and 8%) between physician and paramedic group, respectively. More discharges from ED for paramedic group than physician group (33.1% and 14.7%, p=0.0001) respectively. No difference in trauma severity (RTS) between groups. |
| Mabry R; Afghanistan; 2007–2010 | 3 Retrospective cohort | Mixed | All trauma with ISS >16 (civilians and military) transported by helicopter during either US Army or US Army National Guard deployment. | HEMS double critical care-trained flight paramedic (CCFP) or CCFP/EMT crew | CCFP HEMS crew (n=202) | US Army MEDEVAC HEMS with single emergency technician (n=469). Flight surgeon on board for unspecified number of missions. | Multivariate logistic regression model | Adjusted for ISS, incident location, season and patient category | Mortality at 48 h | Mortality 8% and 15% in CCFP and paramedic group, respectively. After adjusting for covariates, 48-h mortality significantly lower with CCFP treatment (OR 0.34). No difference in trauma severity (ISS) between the groups. |
| Mitchell A; Nova Scotia, Canada; 1998–2002 | 3 Retrospective cohort | Rural | All blunt trauma patients (aged >15 years) with ISS ≥12 transported to one tertiary trauma centre. Includes secondary transfer. | HEMS CCP and registered nurse crew | HEMS transport (n=237, 84% secondary transfers) | Paramedic ground transport (n=554, 44% secondary transfers) | TRISS-based analysis | Insertion of normal physiological values where data was missing. | Mortality (time not specified) | Significantly lower mortality than predicted with CCFP HEMS transport (Z +2.77), significantly higher mortality than predicted with ground transport (Z −1.99). 6.4 more survivors than expected per 100 patients in HEMS group, 2.4 unexpected non-survivors per 100 patients in ground group. |
| Kerr W; Maryland, USA; 1988–1995 | 3 Retrospective cohort | Not specified | All trauma transported to one trauma centre. Includes 17% secondary transfer. | HEMS single paramedic crew with additional training including use of ventilators, ETCO2 monitoring, ETI, IO access, needle thoracostomy and cricothyrotomy. | HEMS transport (n=11 623) | Paramedic ground transport (n=11 379) | direct comparison of ISS-stratified groups | No further adjustment | Mortality predischarge (time not specified) | Mortality for ISS <31 was 4.1% and 3.1% for HEMS and ground transport, respectively (p<0.001). Mortality for ISS ≥31 was 37.1% and 45.3% for HEMS and ground transport, respectively (p<0.001). |
| Study ID | Type of Study | Cohort Design | Patients Description | Intervention | Control | Outcome | Notes |
|----------|---------------|---------------|----------------------|-------------|---------|---------|-------|
| Wirtz M; 3 | Retrospective cohort | Not specified | All trauma patients >15 years old with ISS > 9, transported by two different HEMS to one trauma centre. Includes secondary transfers. | Nurse/paramedic HEMS crew (n=220) | Nurse/nurse HEMS crew (n=841) | TRISS-based analysis | No further adjustment | Mortality (time not specified) No further adjustment Mortality (time not specified) |
| Bernard S; 2 | Prospective, randomised controlled trial | Urban | All patients with head injury, GCS <9, intact airway reflexes and age >15 attended by an intensive care (MICA) paramedic. | MICA paramedics on ground vehicle | RSI by MICA paramedic (n=160) | RSI in receiving ED (n=152) | Intention to treat | No further adjustment | Extended Glasgow Outcome Scale (GOSe) at 6 months |
| York D; 3 | Retrospective cohort | Not specified | All chest trauma transported to one level 1 trauma centre. Includes secondary transfer. | HEMS paramedic working with flight nurse. Paramedic training or competencies not further specified. | Tube thoracostomy by HEMS paramedic/flight nurse (n=72) | Tube thoracostomy in hospital after ground transport (n=100) | Direct comparison | No adjustments | Complications (bleeding, misplacement or infection) ISS and trauma score Mortality |
| Gardtman M; 3 | Retrospective cohort | Urban | All patient with clinical diagnosis of pulmonary oedema attended by a mobile coronary care unit (MCCU). | MCCU paramedic ± nurse crew | Prehospital care with heart failure protocol including non-invasive ventilation (n=158) | Prehospital care before heart failure protocol (n=158) | Direct comparison Kaplan–Meier curve for survival | No further adjustment | Physiologic and clinical findings at hospital arrival Mortality predischarge and at 1 year 1-year cumulative morbidity |

CCP, critical care paramedic; ED, emergency department; ETI, endotracheal intubation; GCS, Glasgow Coma Scale; HEMS, helicopter emergency medical service; ISS, Injury Severity Score; MICA, mobile intensive care ambulance; MTOS, Major Trauma Outcome Study, used as comparator in TRISS analysis; M-value, indicates how well study population matches that of the Major Trauma Outcome Study (TRISS analysis); RSI, rapid sequence induction of anaesthesia and tracheal intubation; RTS, Revised Trauma Score; TRISS, Trauma and Injury Severity Score (determines the probability of survival of a patient); W-score, Number of unexpected survivors or unexpected non-survivors (TRISS analysis); Z-score, statistically significant difference in mortality if higher than +1.96 or lower than −1.96 (TRISS analysis).
and a single paramedic who was supported by a flight surgeon on an unspecified number of missions. Both groups attended to civilian and military trauma patients, with one crew relieving the other at the end of their rotation. After logistic regression analysis, mortality was significantly less in the CCP group. Mitchell et al. compared CCP HEMS and ground transport of trauma patients to a Canadian tertiary centre. This study reported significantly improved survival in the CCP HEMS group which also included a higher number of secondary transfers compared to the ground paramedic group. Kerr et al. undertook a large database analysis, comparing CCP crews to paramedic ground transport. While the direct comparison for patients with Injury Severity Score (ISS) <31 showed a small but statistically significant higher mortality in the HEMS group, this was reversed for patients with ISS ≥31. Differences between the patient groups included a higher percentage of penetrating trauma in the ground group. Wirtz et al. compared a CCP/nurse HEMS crew with a nurse/nurse HEMS crew, with nurses and paramedics having critical care competencies. A Trauma and ISS-based analysis showed no difference in mortality between the groups.

**Additional critical care skills for CCPs**

We identified three studies which examined the effect of specific interventions delivered by CCPs, of which one showed a significant improvement and two showed no difference in their respective outcomes. The first study by Bernard et al. was a randomised controlled trial of MICA paramedics undertaking prehospital RSI versus basic airway manoeuvres prehospital followed by RSI in the receiving ED. There was no significant difference in the primary outcome with a median Extended Glasgow Outcome Scale (GOSe) score of five and three (p=0.28) for CCP RSI and ED RSI, respectively. The a priori defined secondary outcome of ‘good neurologic recovery’ (GOSe 5–8) was achieved significantly more often in the CCP RSI group (51% vs 39%, respectively, p=0.046). York et al. compared the complication rates and mortality of trauma patients receiving a tube thoracostomy either by a CCP/nurse, HEMS crew, or by physicians in the receiving hospital after ground transport. Complication rates were equal between the groups, with ISS and unadjusted mortality higher in the HEMS group. Gardtman et al. examined the effect of adding a protocol for prehospital heart failure treatment, including non-invasive ventilation, to the competencies of a CCP/nurse team on a mobile coronary care unit (MCCU). While the intervention improved the clinical picture at hospital admission, mortality at discharge and at 1 year were unchanged.

**DISCUSSION**

**CCP versus physician-led care**

Baxt’s study has been frequently cited as a justification for including physicians in HEMS crews. The quasirandomisation (not achieved by other studies) and the fact that the nurse crewmember in the CCP and the physician group were capable of the same procedures as the physicians makes this a compelling argument. However, Baxt relates the differences in outcome partially to the fact that the paramedic in the nurse/CCP HEMS crew had significantly less competencies, which excluded thoracostomy, cricothyrotomy or extended medications available only to the nurses and physicians. The other potential factor was the positive effect of physician decision making beyond rigid prehospital protocols. Similarly, the CCPs scope of practice in Garner’s study did not include potentially life-saving interventions, such as RSI or blood transfusions, which were received by 42% of patients in the physician group. While recognising these differences, Garner argues that even when paramedics and physicians were able to achieve an intervention such as IV fluid replacement in hypotensive trauma patients, this was done more aggressively by the physicians. However, this comparison is again influenced by the availability of blood products, and is an interesting finding in view of the current trend towards limiting intravenous fluids in trauma patients. Both these studies have been cited in support of physician staffing of helicopters. However, one could argue that they point to better outcomes with increased procedural skills, training and experience rather than the inherent superiority of a particular professional group.

This view would be supported by the publications from Hamman et al. and Cameron et al., which explicitly state that their HEMS CCPs have significant critical care experience. Despite some differences in procedural capacity between CCPs and physicians (including RSI and tube thoracostomy), both report no differences in mortality. Both studies investigate CCP HEMS crews after removal of a physician from the HEMS crew. This might influence the results in favour of CCPs, as general advances in trauma care, including in-hospital management, might have biased the outcomes. Another possibility is that these CCPs worked alongside prehospital physicians for a significant period before then being dispatched on their own. Physician review and feedback of paramedic practice has been shown to improve paramedic decision making.

The third study to show superior outcomes for physicians compared to CCPs is the evaluation by Schmidt et al. of an American and German HEMS. One major confounding factor is the absence of penetrating trauma in the German patient cohort, while the cause of unexpected deaths in the USA system was mostly the result of penetrating trauma to the head. Together with differences in dispatch times and the lack of description of USA HEMS paramedic competencies, it is very difficult to attribute effects on outcomes to the HEMS staffing alone.

**CCP versus non-physician-led care**

The applicability of Mabry’s study is limited by its setting within military conflict, however, it is the only publication comparing CCP and paramedic care on the same transport platform. The better survival rate in the CCP group can be explained by a number of factors beyond advanced procedural capability of the CCPs. The most obvious of these is the difference in training and experience. The CCPs had an average of 9 years experience and critical care training, whereas the paramedics might have had as little as 1 year of clinical practice prior to deployment. Additionally, CCPs had an extensive clinical governance system with regular peer review and medical director feedback in place. By contrast, supervision of the paramedic group was the responsibility of flight surgeons, often primary care trained, with ‘little or no experience in EMS medical direction, trauma or critical care’. These physicians also attended an unspecified proportion of missions in the paramedic group. It should be noted that the CCP group was always a dual crew, whereas the paramedic group was single-crewed for a large proportion of missions. Mitchell’s study also shows that CCPs achieve better outcomes than paramedics, however, several other factors might have influenced this. First, 84% of HEMS missions (and 44% of ground transports) in this study were transfers from other facilities where patients would have received treatment not controlled for in this study. Additionally, the impact of helicopter versus ground transport needs to be considered. The actual effect of speed of transport by helicopter remains debatable.
but is likely to be more significant in the rural setting of this study. The actual impact of CCP attendance is, therefore, difficult to measure.

Kerr’s comparison of CCP HEMS and paramedic ground transport found an absolute reduction in mortality of 8.2% in trauma patients with ISS \( \geq 31 \) in the HEMS CCP group. While this is encouraging, the statistically significant mortality increase of 1.0% for patients with ISS \(< 31\) in the HEMS CCP group needs to be addressed. The authors do not offer an explanation, and while these dichotomous results could be a statistical anomaly, the large sample size of the study makes this less likely.

A possible explanation is that the risks of advanced interventions, when applied indiscriminately in non-critical situations, outweigh their benefit. Dispatch of critical care teams by helicopters has been shown to be of no benefit to non-critical patients, and careful consideration to the appropriateness of all prehospital interventions is mandatory.

Finally, Wirtz et al compared nurse/CCP and nurse/nurse HEMS crews; nurses and CCPs had equal competencies and freedom of decision making. Not surprisingly, no difference in outcomes was found between the groups, supporting the argument that comprehensive protocols, training and experience are essential for optimal procedural capability. Regular exposure to critical care and injury patients is vital to maintain skills and decision making after initial training. Finally, a robust clinical governance system with feedback, clinical review and medical oversight will identify and address problems and strengthen clinical and decision-making skills. EMSs in which these conditions are provided, have demonstrated encouraging results for CCPs. Any EMS considering the introduction of critical care skills, be it through paramedics, physicians, or nurses, should consider whether it can deliver this level of support to their prehospital providers.

CONCLUSION

CCPs are a group of paramedics with critical care skills who are dispatched to severely ill and injured patients. As is the case for many aspects of prehospital care, there is currently only limited evidence to support this model. The best available evidence suggests a benefit from prehospital RSI carried out by CCPs in patients with severe traumatic brain injury, but the impact of CCPs on long-term outcomes remains unclear for many conditions, and further high-quality research in this area would be welcome.

The evidence reviewed indicates that CCPs are able to deliver care to critically ill and injured patients that is superior to care delivered by paramedics and nurses without additional training and competencies. Whether CCPs can achieve the same standards as doctors trained in prehospital medicine remains unclear, but seems possible under certain conditions. High-quality training in procedures, up-to-date protocols and access to the relevant critical care equipment and medications are essential for optimal procedural capability. Regular exposure to critically ill and injured patients is vital to maintain skills and decision making after initial training. Finally, a robust clinical governance system with feedback, clinical review and medical oversight will identify and address problems and strengthen clinical and decision-making skills. EMSs in which these conditions are provided, have demonstrated encouraging results for CCPs. Any EMS considering the introduction of critical care skills, be it through paramedics, physicians, or nurses, should consider whether it can deliver this level of support to their prehospital providers.

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Competing interests JW works as critical care paramedic within South Western Ambulance Service. Both, JB and JvV-F work closely with critical care paramedics in their clinical and academic practice.

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