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Review Article

Transport of the patient with trauma: a narrative review

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Summary

Trauma and injury place a significant burden on healthcare systems. In most high-income countries, well-developed acute pre-hospital and trauma care systems have been established. In Europe, mobile physician-staffed medical teams are available for the most severely injured patients and apply a wide variety of lifesaving interventions at the same time as ensuring patient comfort. In trauma systems providing pre-hospital care, medical interventions are performed earlier in the patient journey and do not affect time to definite care. The mode of transport from the accident scene depends on the organisation of the healthcare system and the level of hospital care to which the patient is transported. This varies from `scoop and run´ to a basic community care setting, to advanced helicopter emergency medical service transport to a level 4 trauma centre. Secondary transport of trauma patients to a higher level of care should be avoided and may lead to a delay in definitive care. Critically injured patients must be accompanied by at least two healthcare professionals, one of whom must be skilled in cardiopulmonary resuscitation and advanced airway management techniques. Ideally, the standard of care provided during transport, including the level of monitoring, should mirror hospital care. Pre-hospital care focuses on the critical care patient, but the majority of injured patients need only close observation and pain management during transport. Providing comfort and preventing additional injury is the responsibility of the whole transport team.

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Introduction

Globally, trauma is a leading cause of death and has significant impact on individuals as well as healthcare systems. The World Health Organisation (WHO) reports that more than 1.3 million people die on roads every year and as many as 50 million others are injured [1]. Traffic accidents were the most commonly reported cause of trauma, although these have decreased by 25% in the last 25 years. Falls and workplace accidents are reported as the second most common cause [2].

Emergency medical services (EMS) can include local, regional or international systems for delivery of pre-hospital care. They play an important role in improving the outcome of critical emergency care. The availability of pre-hospital care creates a 25% reduction in mortality alone, with a larger cumulative effect when safe transport is combined with prompt facility-based emergency care [3]. The organisation and provision of EMS varies from country to country but all severely injured patients need transport from the site of injury to a definitive care facility as quickly and safely as possible. The benefits of a long-distance transfer to definitive care must be weighed against the associated costs and risk (both for patients and healthcare systems), the time required for evacuation, the expenditure of human resources, the patient's level of discomfort and the likelihood that the patient will survive the journey. Correct

identification of the severity of the injury, with subsequent prioritisation of medical management and determination of the appropriate destination facility, can all impact on morbidity and mortality. There is little or no evidence around triaging for definitive medical care, mode of transport or management during transport [4]. This paper describes the methods and practices for transport of injured trauma patients based on the best available evidence and expertise of the authors.

Acute care systems

These largely depend on the economic development of the country. Pre-hospital care, acute hospital care and quality assurance are classified using the WHO Trauma System Maturity Index in four levels, from 1 (least mature) to 4 (most mature). In the majority of high-income countries, well-developed and mature acute pre-hospital and trauma care systems have been established. Different EMS participate within these systems, some of which have helicopters (helicopter emergency medical service, HEMS) or even fixed-wing aircrafts at their disposal to provide care [5]. Dispatch operators regularly manage regular EMS and additional, physician-staffed assistance by (helicopter) mobile medical teams, as part of an integrated chain of pre-hospital care. However, in low-income countries, trauma systems are typically level 2/3 and there is a lack of dedicated trauma centres and teams [6]. An essential factor in these additional modes of transport is that they are incorporated into regular care [5, 7, 8]. In the Netherlands, 65% of the population has access to specialist medical care within 20 min, provided by one of the four available HEMS-teams 24 h per day. These teams are deployed by the emergency dispatch service, which runs in parallel to ground ambulances, as either primary deployment or secondary deployment on request of the EMS personnel at the scene. The ultimate goal of helicopter transport is to bring additional specialist medical care to the scene of the critically ill or injured patient. If, after initial assessment, the EMS nurse judges that specialist medical care is unnecessary, the HEMS-deployment is cancelled. Within the Dutch system, the medical crew comprises of a physician (anaesthetist or trauma surgeon) and a specialist nurse who is also a HEMS crew member. Other European HEMS teams may have a different composition of personnel.

The HEMS team has a large operational range and can help in decisions around how to transport the patient to the most appropriate hospital either by air or ground using the correct consideration in terms of safety, availability and utility [9, 10]. The decision about whether to transport a medical crew or patient by ground or air depends on the available options and can be a highly complex one, dependent on organisational and patient factors. Time is always of critical importance in the treatment of a severely injured patient. Factors such as road conditions, traffic, weather and location of the trauma centre all influence the choice of transport. Geographical information systems may support this decision, impacting patient outcome and also healthcare expenditures [11].

In selected patients with severe thoracic injury or traumatic brain injury, there is a significant survival benefit when transported by HEMS physicians, even when paramedic ground-based transport might be faster [12, 13]. These patients probably benefit from advanced airway and chest trauma management [14, 15]. The requirement for lifesaving interventions during transport is also an important factor in decision-making. In the cramped and noisy working space of a helicopter, it is not easy to perform tracheal intubation, thoracostomy or resuscitative thoracotomy in a patient who is initially stable but deteriorates during transport. If immediate lifesaving damage control surgery is required, air transport can be time- and lifesaving.

Physician vs. non-physician treatment in the pre-hospital period

In most of the world, pre-hospital care for major trauma patients is delivered by emergency medical technicians and paramedics. Treatment protocols facilitate the provision of a good standard of care in most emergencies. However, limitations in knowledge, skills and experience preclude the use of some lifesaving treatments. In addition, there may be legal barriers to a practitioner's scope of practice. In patients with severe trauma, current evidence suggests benefit from physician-delivered pre-hospital treatment [14]. In Europe, the expertise of this doctor can vary due to the differences in training, local organisation of care and financial resources.

Although paramedics may have considerable diagnostic and interventional proficiency, physicians have additional competencies enabling them to perform pre-hospital anaesthesia, procedural sedation, advanced cardiovascular management and invasive interventions such as establishing a surgical airway, resuscitative thoracotomy, peri-mortem caesarean section and performing peripheral nerve blocks. Clinical exposure in both the pre-hospital and in-hospital setting is of paramount importance in developing these competencies and gaining experience in the treatment of severely injured patients.

Many studies have investigated the impact of physicians in the pre-hospital period and subsequent

transport to definitive care. Several of these studies have been brought together in reviews and meta-analyses. Unfortunately, methodological weaknesses and wide heterogeneity in populations limit the clinical utility of this work and debate continues on this subject. A systematic review by Galvagno et al. included 38 studies [15]. Their goal was to determine if physician-staffed HEMS improved morbidity and mortality for adults with major trauma compared with ground-based EMS. Around half of the included studies found a mortality benefit in the physician-staffed HEMS group. In the other studies, no difference was demonstrated. None of the studies demonstrated a mortality benefit in the patients transported by ground. One publication included 10 reviews [7] and demonstrated that physicians had higher tracheal intubation success rates compared with paramedics. Treatment given by physicians was associated with increased survival in patients suffering out-of-hospital-cardiac-arrest and trauma.

The trial conducted by Davis showed that suboptimal performance of rapid sequence intubation and subsequent ventilation efforts by less skilled personnel increased mortality in adult patients with severe traumatic brain injury [16]. Pre-hospital airway management in children delivered by inexperienced personnel showed an unacceptable intubation failure rate of more than 50% [17]. One reason for the disappointing results of airway procedures might be changes in education and training [18]. In contrast, pre-hospital interventions by anaesthetists have demonstrated lower mortality and better neurological outcomes [19]. The aforementioned findings have given rise to the discussion as to whether paramedics should continue to perform tracheal intubations.

Managing ABCDE and handover

Treatment should be directed towards clear resuscitation end-goals, as determined by the nature of the injury. In general, focus should be on damage control. Medical treatment should be aimed at the optimisation of oxygen transport, monitoring and controlling haemodynamics, correcting coagulopathy and preventing and treating hypothermia. The ATLS-ABCDE approach has become a doctrine of modern trauma care and its principles are also used in the initial assessment of critically ill patients in the pre-hospital domain. This approach, while strict and rigid, can guide inexperienced physicians in the care of the severely injured patient, allowing them to treat life-threatening injuries, stabilise patients and transfer to definitive care [20].

Over the last few years, the rigid ABCDE dogma has shifted towards `resuscitate before you intubate´, with increasing focus on optimising pre-intubation haemodynamic status and oxygenation, before advanced airway management is undertaken using a modified pharmacological strategy [21]. The importance of first-pass intubation success cannot be overstated [22, 23]. Airway management influences the physiologic response during and after tracheal intubation and the transition from spontaneous to positive pressure ventilation increases intrathoracic pressure, leading to hypotension through decreased venous return and cardiac output. This, in combination with inadequate pre-oxygenation, loss of sympathetic tone and multiple intubation attempts, may eventually lead to peri-intubation cardiac arrest [24, 25].

Despite the success story of ATLS and its motivated practitioners around the world, it has never been conclusively proven that this treatment approach actually brings the time savings and improvement in outcomes that might be expected [26]. However, since all healthcare workers are trained to use the ABCDE approach, it can facilitate communication among staff.

Handover is a high-risk process. Professional, social, environmental and human factors can all influence this and are amplified in the pre-hospital setting where staff operate in a potentially dangerous environment with limited resources and clinical capabilities. The WHO identified poor communication as a patient threat and highlighted it as a priority area for research [27]. The use of the standardised situation, background, assessment and recommunication (SBAR) communication tool has been endorsed for handover among healthcare professionals. Implementing a standardised communication tool is complex and requires education and culture change to sustain its use.

Time spent `on-scene´

The balance between the delivery of lifesaving treatment and minimisation of pre-hospital time can be difficult to get right. In a trauma system in which pre-hospital critical care is provided, longer pre-hospital or on-scene time is mitigated by reduced time to hospital interventions. Urgent medical interventions are performed earlier in the patient's journey and may not affect time to definite care [28].

There are many controversies around delivery of pre-hospital medical interventions, with different studies demonstrating conflicting results [11, 12, 15, 17, 29–31]. Most pre-hospital interventions take place during transport, limiting the on-scene time. However, an increase in on-scene time is not always linked to increased mortality [29, 32], especially when the patient is transported to the appropriate definitive care facility [8, 12, 13]. Bedard et al. recently evaluated the effect of on-scene time on trauma

outcomes. They included 96 studies, predominantly observational, with conflicting conclusions ranging from positive, negative and neutral impact from on-scene time [33].

Mode of transport

The primary purpose of transporting the critically injured trauma patient to the appropriate facility is the prevention of morbidity and mortality [4, 6, 34]. Good infrastructure, reliable communication systems and well-equipped vehicles are key to this aim. Time from accident to arrival at hospital is often minimal. In patients with certain mechanisms of injury such as penetrating trauma, who are in haemorrhagic shock, this `scoop and run´ tactic can be lifesaving [20, 35].

Currently, most trauma patients are transported from an accident site to the hospital emergency department by ground ambulance, with paramedics providing care at the scene of the incident. A severely injured patient, as defined by an injury severity score of > 16, should be transported by at least two attendants of whom one should be competent in resuscitation and airway management [36]. Trauma patients may be transported to different levels of hospital care ranging from basic community care only to a level-4 trauma centre. After initial treatment, secondary inter-hospital transfer to definitive care may be needed. The pre-hospital Trauma Triage app, a smartphone application, may support triage decisions in pre-hospital care and may avoid secondary transfers [37].

Monitoring during transport

The degree of monitoring for trauma patients during transport will be determined by the severity of the illness of the patient and availability of monitoring equipment. Modern, sophisticated ventilators, monitoring equipment and syringe drivers are relatively small and occupy little space. Expert knowledge of their function and use remains essential [36]. There are few guidelines detailing the use of transport monitoring and those available require an update. The most recent comes from Australia and is a joint publication from the Australasian College for Emergency Medicine, the Australian and New Zealand College of Anaesthetists and the College of Intensive Care Medicine of Australia and New Zealand [38]. Standard monitoring during patient transport consists of continuous monitoring and registration of arterial oxygen saturation by pulse oximetry, respiration rate, heart rate, electrocardiography, and non-invasive blood pressure measurement. Additionally, temperature must be monitored and point-of-care testing may be indicated, such as diagnostic ultrasound imaging, glucose and blood gas analysis. In an intubated patient, end-tidal carbon dioxide partial pressure and ventilation parameters should be monitored. Invasive haemodynamic monitoring is often used during intensive care transport.

Secondary or inter-hospital transport using HEMS

To receive definitive care, secondary transport of trauma patients is a standard operating procedure incorporated into modern trauma care systems [39]. Delays can be frequent in the planning, transport and handover phases. These delays may be more common out of hours, when a reduced number of physicians is present [10, 40]. The intended benefit of transferring patients to a higher level of care is therefore not always achieved [40, 41].

In addition to the transport of trauma patients to a higher-level trauma centre, secondary transport is also used for redistributing intensive care patients when there is a critical care bed shortage, as seen during the recent COVID-19 pandemic. Special HEMS-transport helicopters for long-distance transfers were used in the Netherlands.

Patient comfort during transport

Medical specialist pre-hospital care mainly focuses on the critical care patient, but the majority of injured patients require transport without the need for mechanical ventilation or inotropic support. Although haemodynamically stable, these patients may suffer from major injuries including thoracic and abdominal contusions, complex fractures or amputations. Close observation of respiratory and haemodynamic function are required, as well as aggressive pain management during transport.

Since pain and anxiety are multifactorial in origin, it can be difficult to provide generalised treatment protocols for an individual [42]. Identified barriers to effective pain management are knowledge deficits, pain assessment challenges, pain underestimation, healthcare professional beliefs and attitudes, patient refusal of pharmacological treatment and organisational aspects. Legal concerns may hinder the administration of opioids by non-physicians, but teleconsultation of a physician may overcome this problem and is effective and safe [43].

Most EMS protocols follow the WHO analgesic ladder and recommend paracetamol as the treatment of choice for mild pain in children and adults. For moderate and severe pain management, fentanyl and morphine are suggested. The route of administration is variable, but not everyone is comfortable using all routes [42]. In patients with a

threatened airway or haemodynamic compromise, ketamine is advised [44].

The vibrations, bouncing and noise of the continuously moving ambulance or helicopter may worsen pain and patients can experience inadequate pain control. In qualified hands, additional techniques for pain management, such as peripheral nerve blocks, can be used in the pre-hospital period [45]. Fracture reposition reduces pain and blood loss and is best achieved with a peripheral block. Vigilance is required when performing peripheral nerve blocks in patients with extremity injuries because of the risk of compartment syndrome. In such patients, an adapted treatment regimen is advised, using lower concentrations of local anaesthetic drugs. Close surveillance and early fasciotomy are required in patients at high risk of developing an acute compartment syndrome.

Providing comfort encompasses more than just pain relief. First, patients may become cold in the ambulance and benefit from active warming [46]. Second, motion sickness can be problematic during ambulance or air transport. Rear facing positions are more often associated with motion sickness than forward-facing ones. Providing passengers with a view of the outside reduces motion sickness, although severe motion sickness can occur despite a clear view of the road ahead [47]. Although frequently administered in pre-hospital care, D2-dopamine receptor antagonists and 5-HT3 antagonists are not effective against motion sickness. This is probably because their sites of action are at vagal afferent receptors or the chemoreceptor trigger zone in the brainstem rather than at the vestibular brainstem-cerebellar areas [48]. Motion can expose the patient to the risk of vomiting and aspiration, which is a particular threat for patients with spinal immobilisation, especially during helicopter transport. The limited space and obligate belt fixation make it impossible to place the patient in a lateral recumbent position and maintain spine alignment. This is an important consideration when choosing the mode of transport. Finally, high noise exposure levels occur during use of sirens or helicopter flying, and affect patients and healthcare professionals. These levels often exceed the recommendations described in the European Regulative for Noise and require protective initiatives [49]. Better noise insulation of ambulances, wearing of custom made in-ear protection for HEMS personnel and application of hearing protection by ear plugs for patients transported by helicopter may prevent hearing loss.

Personnel involved in the transport of patients should evaluate interventions designed to minimise pain and anxiety using patient-related outcome measurements. Already introduced in the emergency department, introducing these in pre-hospital care may prove to be more challenging [50].

In conclusion, the transport of trauma patients is a complex process influenced by many factors. The care provided during transport varies depending on the available healthcare systems and organisation. The composition and knowledge of the emergency medical teams can vary, as well as mode of transportation. Both play an important role in improving the outcomes of acute emergency care. Immediate and precise identification of injury severity, with correct prioritisation of medical treatment and identification of the best mode of transport from accident scene to definite care, may impact morbidity and mortality.

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