Modern concepts of transport in multiple trauma: a narrative review

Mohammad Reza Zarei, Kourosh Karimi Yarandi, Mohammad Reza Rasouli, Vafa Rahimi-Movaghar*

【Abstract】Multiple variables can influence triage decision in multiple trauma. Recognition of priorities and selection of the destination can be successfully achieved by field triage and individualized clinical judgment. This narrative review summarizes the new options and protocols for transport of injured subjects. There are four levels of emergency medical providers including first responders and three levels of emergency medical technicians. Two distinct accepted protocols for transport are known as scoop and run and treat and then transfer. The former provides minimum lifesaving treatment at the scene of accident followed by transferring the patient(s) as soon as possible, and the latter mainly emphasizes the need for complete stabilization as a prerequisite for safe transport. The destination and mode of transport are selected according to clinical capabilities of the receiving hospital, transfer time from the scene to the facility, patient’s medical condition, accessibility of the scene, and weather. Two common methods of transfer are ground transport, including various type of ambulances, and air medical transport, i.e. helicopter and airplane.

Key words: Transportation of patients; Multiple trauma; Triage; Emergency medical service communication systems

Recent motorization of the societies has converted multiple trauma into a common cause of mortality and morbidity in both developed and developing countries. According to numerous reports, transferring the trauma patients as soon as possible and considering a prioritized protocol of recognition and treatment can play a significant role in improving survival. Consequently, this will decrease the associated expense related to medical care and the rate of probable subsequent disabilities of the victims, who are frequently young and active.

Recently, the development of various levels of trauma care centers, training different ranks of emergency medical providers, innovation of triage protocols, availability of advanced types of transport and modern equipment, introduction of different approaches of prehospital care, and demonstration of important safety issues have complicated the decision of where a trauma patient should be transported to, when the decision to terminate the primary resuscitation and commence the transport should be made, how a subject should be transported, and who should be transferred first. This review aims to summarize the new options and protocols for transport of injured individuals according to the recent studies published in the literature.

Triage

It is proposed that giving care to injured individuals in a trauma center can improve their outcome comparing to the ordinary non-trauma centers. Trauma centers are classified into four levels. The definition of a level I trauma center includes: (1) it is a regional resource hospital central to trauma care system; (2) provides total care for every aspect of injury, from prevention to rehabilitation; (3) maintains resources and personnel for patient care, education and research (usually in university-based teaching hospital); and (4) provides leadership in education, research, and system plan-
ning to all hospitals caring for injured patients in the region. A level II trauma center needs to meet these requirements: (1) it provides comprehensive trauma care, regardless of the severity of injury; (2) might be the most prevalent facility in a community and manages majority of trauma patients or supplements the activity of a level I trauma center; (3) can be an academic institution or a public or private community facility located in an urban, suburban, or rural area; and (4) is responsible for education and system leadership when no level I trauma center exists. While a level III trauma center has these functions: (1) it provides prompt assessment, resuscitation, emergency surgery, stabilization and arranges transfer to a higher-level facility when necessary; (2) maintains continuous general surgery coverage; (3) has transfer agreements and standardized treatment protocols to plan for care of injured patients and (4) might not be required in urban or suburban area with adequate level I or II trauma centers. As for level IV trauma center, its definition includes: (1) it is a rural facility that supplements care within the larger trauma system; (2) provides initial evaluation and assessment of injured patients; (3) must have 24-hour emergency coverage by a physician; and (4) has transfer agreements and a good working relationship with the nearest level I, II, or III trauma centers.1

The main factors determining the timing of transport and appropriate destination include the patient’s medical status and severity of injury,2 distance between the location of accident and the higher level trauma center,3 and deciding upon the most appropriate destination hospital for the patient.4 Patients who are taken to a level I center enjoy better survival and functional outcomes comparing to those transferred to level II trauma centers.5,7

The American College of Surgeons (ACS), the Injury Control Center of the Centers for Disease Control, the American College of Emergency Physicians, and many other qualified organizations developed a trauma triage and destination tool that is recommended to be used by prehospital care providers and trauma systems. This protocol is an algorithm that guides emergency medical service (EMS) providers through four decision steps (physiologic, anatomic, mechanism of injury, co-morbid factors and special considerations) to select the most suitable destination within the local trauma care system.3

As the first step, it is suggested to rapidly identify critically injured patients by measuring the vital signs and assessing the level of consciousness and then to transport them to a trauma center. The mechanisms which are considered as the indications of transport to a trauma center are shown in Table 1.1,3,8 During the second step, more detailed evaluation of the victims reveals further indications of patient transfer which are also demonstrated in Table 1.4 EMS providers transfer these cases to the available highest level trauma center (i.e. a level I or II facility). Patients who do not fulfill the step 1 and 2 transport criteria may still have severe, but occult injuries. In the third step, the mechanism of injury should be evaluated to determine whether the injured person should be transported to a trauma center or not.

The mechanistic criteria for evaluation at a trauma center are appropriate when an acceptable annual number of trauma patient triage is achieved based on the hospital’s personnel, instruments and budget to care of patients as well as subsequent complications.9 In patients who do not meet the criteria of these steps, EMS personnel should distinguish cases with underlying conditions or co-morbid factors that place them at higher risk for severe injury (Table 1). Subjects with such underlying conditions still require advanced care in a trauma center.10

It is recommended to include the crash scene information in trauma triage protocols.11 Meanwhile, the value of mechanism of injury such as rollover12 and intrusion13 of motor vehicle crashes is criticized by some investigators for their lack of sensitivity to occult injuries. The majority of these patients should be safely evaluated and treated at non-trauma centers or transferred later.12

**EMS providers**

The roles of EMS providers include prevention of additional injury, rapid transport to the hospital, advance notification to the destination, initiation of treatment, and triage. There are four levels of emergency medical technicians (EMTs, Table 2). Recent studies demonstrate that early, in-field basic life support (BLS) by paramedics improves survival following trauma whenprehospital transport time is long.14 Paramedics can apply the Canadian C-Spine Rule reliably without missing any important cervical spine injuries. The adoption of this rule can significantly reduce the number of unnecessary out-of-hospital cervical spine immobilizations.15 The primary care
provider in serious prehospital medical emergencies can be physicians, basic EMTs or paramedics (specially trained advanced trauma life support providers).\textsuperscript{16,19} gives an emphasis to transferring the patient as soon as possible to an appropriately staffed and equipped trauma unit in order to treat the injuries properly.\textsuperscript{20,21}

**Scoop and run vs. Treat and transfer**

Two treatment strategies have been recommended to approach the victim in prehospital care. They have become known as *scoop and run* and *treat then transfer (stay and play).*\textsuperscript{20} The former approach provides only minimal lifesaving treatment at the site of accident and gives an emphasis to transferring the patient as soon as possible to an appropriately staffed and equipped trauma unit in order to treat the injuries properly.\textsuperscript{20,21}

Regardless of the selected approach, field stabilization should be recognized as an essential component of good prehospital care. The treatment of the severely injured patient in the prehospital phase should consist of assessment, extrication, initiation of resuscitation and rapid transport to the closest appropriate facility.

**Table 1.** Indications for patient transfer to a trauma center according to field triage decision scheme developed by the ACS

<table>
<thead>
<tr>
<th>Step</th>
<th>Indications of transfer to a trauma center</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step 1</td>
<td>Glasgow coma scale (GCS) less than 14; systolic blood pressure below 90 mm Hg; respiratory rate less than 10 or more than 29 breaths per minute (below 20 in infants aged less than 1 year)</td>
</tr>
<tr>
<td>Step 2</td>
<td>Penetrating injury to head, neck, trunk and extremities proximal to elbow and knee; flail chest; two or more proximal long-bone fractures; crushed, degloved or mangled extremity amputation proximal to wrist and ankle; pelvic fracture; open or depressed skull fracture; paralysis; major burns</td>
</tr>
<tr>
<td>Step 3</td>
<td>Falling from more than 20 feet of height (for children aged less than 15 years, more than 10 feet of height or two to three times of child’s height); high-risk auto crash: intrusion of more than 30 cm to the occupant site or more than 45 cm to any site, ejection from automobile, death in the same passenger compartment, and vehicle telemetry data consistent with high risk of injury; auto versus pedestrian/bicyclist (thrown, run over, or at a speed of at least 30 km/h); motorcycle crash at a speed of more than 30 km/h</td>
</tr>
<tr>
<td>Step 4</td>
<td>Age (above 55 years or below 15 years); anticoagulation and bleeding disorders; cardiac or respiratory disease; insulin dependent diabetes mellitus; cirrhosis; morbid obesity; immunosuppression; burns; time-sensitive extremity injury; end-stage renal disease requiring dialysis; more than 20 weeks of pregnancy; need for special care according to EMS provider’s judgment</td>
</tr>
</tbody>
</table>

**Table 2.** Different levels of EMS providers

<table>
<thead>
<tr>
<th>Level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1: First responders</td>
<td>Can preserve the airway, perform assisted ventilations and cardiopulmonary resuscitation (CPR), and control hemorrhage.*</td>
</tr>
<tr>
<td>Level 2: EMT-Basic</td>
<td>Provides above-mentioned skills and performs patient assessment, administers oxygen, assists ventilation using a bag-mask device, immobilizes the spine, and transports the victim.**</td>
</tr>
<tr>
<td>Level 3: EMT-Intermediate</td>
<td>Trained to an intermediate level between EMT-Basics and paramedics. EMT- Intermediates are providers of BLS and possess all the skills of EMT-Basics. In addition they are also trained to use an automated external defibrillator.***</td>
</tr>
<tr>
<td>Level 4: EMT-Paramedic</td>
<td>Trained to obtain vascular access and deliver medications via inhaled, intraosseous, intravenous, intramuscular, and endotracheal routes. Paramedics perform endotracheal intubation as well.****</td>
</tr>
</tbody>
</table>

*Trained amateur first responders improve trauma outcomes when prehospital evacuation time is long. In places with high prevalence of severe trauma, firstly responders should be an essential element of the trauma system.**In some EMS systems, EMTs learn to assist in administering epinephrine to treat anaphylaxis, and to administer inhaled bronchodilators. EMT-Basics can be as accurate as paramedics in making decisions regarding selective immobilization of the cervical spine during paper-based scenarios. EMT-Basics are also highly successful in assessing children with injury.***The level of training differs within each EMS system, but EMT-Intermediates may perform endotracheal intubation and obtain vascular access depending on the system.****Even successful non-drug-assisted, prehospital endotracheal intubation can be achieved by advanced care paramedics.
Accordingly, spinal immobilization, proper diagnosis of life-threatening airway and breathing problems, and initial management (e.g. use of high-flow oxygen, aggressive airway management and ventilation) are still mandatory even in the scoop and run strategy. Similarly, temporary field treatment of a tension pneumothorax or cardiac tamponade by needle thoracostomy or pericardiocentesis may be life-saving but transfer should not be delayed by attempts to obtain intravenous access.

*Treat then transfer* is the second strategy mainly emphasizing the need for complete stabilization as a prerequisite for safe transport, although such stabilization can be time consuming and may delay the definite treatment.

Improving the survival rate seems to be related to both rapid response and an advanced level of prehospital medical care, combined with rapid transport to the appropriate trauma center. Both systems have been developed and optimized over decades in special environments and no significant differences in outcome have been detected between the two approaches. Therefore, individualized decision making and clinical judgment can be superior to the available triage methods in determining the optimal point when transfer should occur. In fact, when clinical judgment is used in conjunction with triage criteria, most trauma patients can be identified more reliably.

**Safety issues including spine protection**

Regarding safety issues, the most important point to emphasize is the obligation to ensure safety of the rescuers. Different aspects of safety issues include personal safety, scene safety (to identify any obvious hazards) and patient’s safety.

At the scene of an injury, unstable energy sources can pose a possible threat to the lives of victims and rescuers. They may be clearly apparent as violent assailants, puddles of leaking corrosives, flames, and exposed electrical wires; or they may be more covert, such as an unstable wall, an un-deployed vehicle airbag, a high-tension cable that can be re-energized without warning. The possible presence of such sources not only mandates the discipline to look for them, but also warrants sufficient general knowledge to be able to identify their existence. Medical personnel who are sent to the scene of an injury should be equipped with protective items including fire retardants, high visibility overalls, boots, gloves, helmets and eye protection devices. Similarly, safety during transport should be a main concern in any transport program. Emergency vehicle operation carries extensive risks, not only to the team and the patient but also to others in its surrounding area.

The process of transport should not pose any additional threat to the victim. One of the greatest possible dangers during patient transfer is the aggravation of spine injury. Thus, it is obligatory for the rescue team to be equipped with the components of spinal immobilization. Detailed equipments required for transport of injured patients include: airway management protection equipment, pulse oximeter, cardiac monitoring, intravenous solutions, drugs for resuscitation, accessories such as chest leads, intravenous catheters, tracheal tubes, etc, equipment of physical exam, equipment of resuscitation, long and short spine board with straps, rigid or semi-rigid cervical spine collar, sandbags or other devices to limit head and neck motion, wheeled stretcher, chair, scoop stretcher, flexible, stretcher, bed, and personal protection equipment like fire retardants, high visibility overalls, boots, gloves, helmets and eye protection devices. As for spine board with straps, foam blocks and towels can complement the basic items and improve stability. Padding may improve positioning and comfort. Intermediate-stage devices include the short backboard and newer commercial devices. Moreover, cervical collars are not perfect for immobilization of the cervical spine. These orthoses can relatively reduce flexion and extension movements.

**Destination level**

The destination shall be selected according to the clinical capabilities, transfer time from the scene to the hospital, and the patient’s condition. When the patient’s condition is unstable or life-threatening, i.e. pulselessness, apnea, unstable or unmanageable airway, or rapidly deteriorating vital signs, the patient should be transported to the closest appropriate hospital. Patient’s request, family’s request and physician preference can also be considered in selection of destination.

Nevertheless, the rescuer should not take these requests as the main priority especially when the patient’s condition is unstable.
Selection of the proper destination can be totally different when a mass casualty incident is confronted. A mass casualty incident is able to overwhelm traditional hospital resources that are normally thought as appropriate destinations for the transport of injured patients. Consequently, those with less severe injuries are often required to wait before they can receive definitive treatment. This waiting period either at the scene of incident or in the emergency department can increase morbidity or drain resources that can be better directed toward the transport and care of victims more severely injured. The rescuers may transfer the subjects with less severe injuries to farther centers with lower level of trauma care if their medical status allows. Other possible transport destinations include physician office buildings, ambulatory care centers, ambulatory surgery centers, and urgent care centers. By allowing transport to alternate locations, the less severely injured patients can be removed rapidly from the scene, treated and potentially released.

It should be emphasized that in such situations, the injuries should not be underestimated and the medical status of the subjects who need immediate medical care should not be misdiagnosed as stable.

Types of transportation of patients
The mode of transport for injured patients should be selected according to multiple factors including the patient’s medical condition, distance to the regional trauma center, accessibility of the scene, weather and availability of different vehicles or aircrafts. It should be individualized for each site and each case. The two common types are ground and air transports. Ground transport includes different types of ambulances (BLS, advanced trauma life support) and air medical transport utilizes rotor-wing (helicopter) or fixed-wing (airplane) aircrafts. Ambulances can provide the shortest arrival interval at distances less than 10 miles from the hospital. At distances greater than 10 miles, simultaneously dispatched air transport is faster. It is shown that non-simultaneous dispatched helicopter transport is faster than ground transport if the distance is greater than 45 miles from the hospital.

Three basic ambulance vehicle designs are recognized: both type I and type III ambulances incorporate a modular patient compartment mounted on a conventional truck or van chassis respectively; while the type II vehicle is a standard van. The larger medium-duty vehicle, mounted on a business-class chassis, has become popular in recent years. Basic ambulance equipment should include items necessary for emergency procedures (e.g. airway support, hemorrhage control, fracture and spine immobilization, childbirth), personal protection, patient movement, and basic rescue procedures.

In some developing countries, public or private vehicles may be used for trauma patient transport. Occasionally, patients with severe trauma are transported by private means such as friends, relatives, bystanders, or police.

Helicopter transport has the ability to avoid common traffic delay and ground obstacles and can fly into locations that may be inaccessible to other modes of travel. Rapid utilization of this rotorcraft can have a dramatic impact upon outcome of the severely injured patients and improves their overall survival rates.

In a study, all trauma patients directly transported from the scene of injury to a Level I or Level II trauma center by either air or ground EMS over a 4-year period are selected from the Oklahoma State Trauma Registry. The short term mortality risk in patients transported by helicopter EMS is 33% lower than those transported by ground EMS. Distance is the main factor deciding whether to use air or ground EMS to transport a trauma patient from the scene of injury to a trauma center. GCS <14 and injury etiology are two other important associated factors influencing the decision.

Disadvantages of rotor-wing flight include the presence of noise and turbulence, vibration, and acceleration forces which may interfere with patient evaluation, monitoring and management. Weather considerations may significantly limit the availability of helicopter transport. In small and medium-sized helicopters, cramped patient compartments and weight limitations may compromise optimal patient care. Motion sickness may also be a problem.

Using fixed wing transport has further complexities requiring multiple changes in mode of transport as the team and patient move from ground to air and then to ground transport again.
Equipment

Availability of appropriate equipment has a profound effect on resuscitating and packaging the patient and maintenance of stability during emergency or inter-facility transport. A list of equipment required for transport of injured patients has been abovementioned.

Adverse events may occur during utilization of wheeled stretchers to move patients in the out-of-hospital setting, resulting in significant injury to patients and ambulance personnel. The scoop stretcher and lift-and-slide techniques are able to restrict motion to a comparable degree. The effectiveness of the scoop stretcher to limit spinal motion in the destabilized spine is at least comparable to manual techniques.

Trauma centers have also established direct communication links, using a government radio network between prehospital care providers and the resuscitation room, to facilitate the transfer of information and to allow directed preparation of the trauma team. This radio link is used to advise the trauma team when a patient with hemodynamic instability is to be expected and to outline suspected injuries and initiate treatment.

Conclusion

Appropriate transport of injured subjects is of crucial importance. Familiarity with triage protocols, initial primary assessment, and rapid resuscitation as well as availability of different levels of EMS providers and trauma centers, various methods of transfer, and adequate equipment for patient transport can profoundly improve the outcome and significantly influence the morbidity and mortality of injured patients.

REFERENCES


21. Haas B, Nathens AB. Pro/con debate: is the scoop and run


