Sri Lakshmi Narayana Institute of Medical Sciences

Date: 03.05.2019

From
Head Of Department Incharge
Department of Anaesthesia
Sri Lakshmi Narayana Institute of Medical Sciences
Bharath Institute of Higher Education and Research
Puducherry

To
The Dean,
Sri Lakshmi Narayana Institute of Medical Sciences
Puducherry

Sub: Request for Permission to conduct value-added course: Comprehensive Trauma Life Support

Dear Sir,

With reference to the subject mentioned above, the department proposes to conduct a value-added course titled: Comprehensive Trauma Life Support for undergraduates from July -Dec 2019. We solicit your kind permission for the same.

Kind Regards

Dr. M KALASREE

FOR THE USE OF DEANS OFFICE

Names of Committee members for evaluating the course:

The Dean: Dr JAYALAKSHMI

The HOD: Dr. M KALASREE

The Expert: Dr. CHANDRASEKAR

The committee has discussed about the course and is approved.

Dean　　　　Subject Expert　　　　HOD

Dr. G. JAYALAKSHMI, BSC.,MBBS.,DTCD.,M.D.,
DEAN
Sri Lakshmi Narayana Institute of Medical Sciences
Osudu, Ageram Kudapakkam, Post,
Villanur Commune Puducherry-605 502.

DEPARTMENT OF ANAESTHESIOLOGY
SRI LAKSHMI NARAYANA INSTITUTE OF MEDICAL SCIENCES
OSUDU, KUDAPAKKAM, PUDUCHERRY-605 502

OFFICE OF THE DEAN

Sri Lakshmi Narayana Institute of Medical Sciences

OSUDU, AGARAM VILLAGE, VILLIANUR COMMUNE, KUDAPAKKAM POST,
PUDUCHERRY - 605 502.

[Recognised by Medical Council of India, Ministry of Health letter No. U/12012/249/2005-ME (P -II) dt. 11/07/2011]
[Affliated to Bharath University, Chennai - TN]

Circular

07.06.2019

Sub: Organizing Value-added Courses: Comprehensive Trauma Life Support - reg

With reference to the above mentioned subject, it is to bring to your notice that Sri Lakshmi Narayana Institute of Medical Sciences, **Bharath Institute of Higher Education and Research**, is organizing **"_Comprehensive Trauma Life Support"** course in July- Dec 2019. The course content is enclosed below."

The application must reach the institution along with all the necessary documents as mentioned. The hard copy of the application should be sent to the institution by registered/ speed post only so as to reach on or before 15/06/2019. Applications received after the mentioned date shall not be entertained under any circumstances.

Dean

Dr. G. JAYALAKSHMI, BSC.,MBBS.,DTCD.,M.D.
DEAN
Sri Lakshmi Narayana Institute of Medical Sciences
Osudu, Agaram Kudapakkam, Post,
Villanur Commune Puducherry-605 502.

Encl: Copy of Course content

COURSE PROPOSAL

Course Title: **COMPREHENSIVE TRAUMA LIFE SUPPORT**

Course Objective:

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1. To enable the students to learn about primary and secondary management of trauma patients.

2. To be familiar with recent advances in trauma care including use of USG in management of trauma patients

Course Outcome:

On successful completion of the course the students will have skill in basic management of trauma car.

Course Audience: CRRI

Course Coordinator: Dr Kalasree M

Course Faculties with Qualification and Designation:

1. Dr. Kalasree M-Associate Professor
2. Dr Chandrasekar – Assistant Professor

Course Curriculum/Topics with schedule (Min of 30 hours)

S.No	Date	Topic	Time	Hours	Faculty
1	13.07.2019	Introduction to course	2-4PM	2	Dr Chandrasekar
2	20.07.2019	objectives	2-4PM	2	Dr. Kalasree
3	27.07.2019	Definition of trauma	2-4PM	2	Dr Chandrasekar
4	03.08.2019	Polytrauma	2-4PM	2	Dr. Kalasree
5	10.08.2019	Pre hospital care	2-4PM	2	Dr Chandrasekar
6	17.08.2019	Triage of trauma patients	2-4PM	2	Dr. Kalasree-
7	24.08.2019	Primary and secondary assessment	2-4PM	2	Dr Chandrasekar
8	31.08.2019	Golden hour and platinum hour	2-4PM	2	Dr. Kalasree
9	07.09.2019	Stabilization and optimization	2-4PM	2	Dr Chandrasekar
10	14.09.2019	Trauma team	2-4PM	2	Dr. Kalasree
11	21.09.2019	Damage control surgery	2-4PM	2	Dr Chandrasekar
12	28.09.2019	Lethal triad of death	2-4PM	2	Dr. Kalasree
13	05.10.2019	Massive blood transfusion	2-4PM	2	Dr Chandrasekar
14	12.10.2019	Training of healthcare providers	2-4PM	2	Dr. Kalasree
15	19.10.2019	Final assessment	2-4PM	2	Dr Chandrasekar

REFERENCES:

1) Hoyt DB, Coimbra R. Trauma systems. Surg Clin North Am. 2007.

2. Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, Flint L. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. J Trauma. 2006.

3. Abu-Zidan FM, Dittrich K, Czechowski JJ, Kazzam EE. Establishment of a course for Focused Assessment Sonography for Trauma. Saudi Med J. 2005

VALUE ADDED COURSE

1. Name of the program & Code

COMPREHENSIVE TRAUMA LIFE SUPPORT, ANAES 10

2. Duration & Period

30 hrs: July 2019- December 2019

3. Information Brochure and Course Content of Value Added Courses

Enclosed as Annexure- I

4. List of students enrolled:

Enclosed as Annexure- II

5. Assessment procedures:

Multiple choice questions- *Enclosed as Annexure- III*

6. Certificate of Participation:

Enclosed as Annexure- IV

7. No. of times offered during the same year:

1 Time JULY 2019-DEC 2019

8. Year of discontinuation: 2019

9. Summary report of each program year-wise

Value Added Course- JULY 2019-DEC 2019					
Sl. No	**Course Code**	**Course Name**	**Resource Persons**	**Target Students**	**Strength & Year**
1	ANAES 10	COMPREHENSIVE TRAUMA LIFE SUPPORT	DR. M KALASREE	CRRI	20

10. Course Feed Back

Enclosed as Annexure- V

RESOURCE PERSON

DEPARTMENT OF ANAESTHESIOLOGY
SRI LAKSHMI NARAYANA INSTITUTE OF MEDICAL SCIENCES
OSUDU, KUDAPAKKAM, PUDUCHERRY-605 502

DR. CHANDRASEKAR

COORDINATOR

DR. M KALASREE

Annexure I

INTRODUCTION

Every day, there are any numbers of events that can result in serious injury and cause a person to stop breathing. These occurrences require fast action and people who are knowledgeable and capable enough to provide helpful assistance.

BLS or Basic Life Support as it implies is the basic aid provided to an individual who suddenly loses consciousness and suddenly stops breathing. Basic life support is a first aid measure to maintain the ABCs which stand for airway, breathing and circulation without auxiliary equipment. This is done while waiting for the ambulance or while waiting for medical and professional help.

This is not only advantageous for health care personnel but it is also advantageous for their family as well. This will make health care personnel prepared for any life threatening situation that require basic life support.

When treating injured patients, clinicians rapidly assess injuries and institute lifepreserving therapy. Because timing is crucial, a systematic approach that can be rapidly and accurately applied is essential. This approach, termed the "initial assessment," includes the following elements:

- Preparation
- Triage

• Primary survey (ABCDEs) with immediate resuscitation of patients with life-threatening injuries

• Adjuncts to the primary survey and resuscitation

• Consideration of the need for patient transfer

• Secondary survey (head-to-toe evaluation and patient history)

• Adjuncts to the secondary survey

• Continued post resuscitation monitoring and reevaluation

• Definitive care

The primary and secondary surveys are repeated frequently to identify any change in the patient's status that indicates the need for additional intervention. The assessment sequence presented in this chapter reflects a linear, or longitudinal, progression of events.

In an actual clinical situation, however, many of these activities occur simultaneously. The longitudinal progression of the assessment process allows clinicians an opportunity to mentally review the progress of actual trauma resuscitation.

Objective

Basic life support is needed when:

The individual is unconscious ∑

There is no presence of breathing (observe if there is the rise and fall of chest or feel the victim's nose or mouth for air) ∑

Abnormal pulse rate (thready or very fast)

The **primary objective** in basic life support is to establish and maintain an open airway to restore breathing and to correct respiratory acidosis (the carbon dioxide levels are higher than the oxygen levels).

An open airway is achieved by removing the object that impedes with the victim's breathing. If there is no object that is blocking the airway, this might involve a heart condition so chest compressions are required. This is applying pressure on to the victim's chest (with proper positioning of the hands on the correct location) to maintain the normal transport of oxygen to the brain and vital organs.

Oxygen deprivation is fatal especially when 6 minutes or more has passed since irreversible brain damage has occurred already and the chances of survival slim down. Importance of BLS Training: Current studies show that there is a significant lack of knowledge regarding the typical signs and risk factors associated with serious medical conditions among medical students and laypersons.

Basic life support consists of a number of medical procedures provided to patients with life threatening conditions of the body that cause pain or dysfunction to the person. Understanding BLS courses and more than that, practicing these techniques is by far the most challenging task confronting first aid. Taking everything into consideration, we believe that an adequate education in first aid and basic life support should be considered an essential aspect of the medical curriculum. CPR is a life-saving technique that is used when someone’s heart has stopped. Some medical conditions, such as a severe heart attack, can cause the heart to stop. Other causes include drowning, electric shock, poisoning, overdose and serious injury. For CPR to be successful, it needs to be started as soon as possible after a person's heart stops.

Objective: on completive course the student will be able to: ∑

know when and how to apply CPR for an adult, child and baby ∑ know what to do if someone is choking ∑

manage serious bleeding until medical help arrives ∑

how to do primary assessment for CPR ∑

how to meet the health & safety structures.

BLS includes psychomotor skills for performing high-quality cardiopulmonary resuscitation (CPR), using an automated external defibrillator (AED) and relieving an obstructed airway for patients of all ages. BLS does not include the use of drugs or invasive skills, and can be contrasted with the provision of Advanced Life Support (ALS). Firefighter, lifeguards, and police officers are often required to be BLS certified. BLS skills are also appropriate for many other professions, such as daycare providers, teachers and security personnel and social workers especially working in the hospitals and ambulance drivers. CPR provided in the field increases the time available for higher medical responders to arrive and provide ALS care. An important advance in providing BLS is the availability of the automated external defibrillator or AED.

This improves survival outcomes in cardiac arrest cases.

[1] Basic life support promotes adequate blood circulation in addition to breathing through a clear airway: ∑

Circulation: providing an adequate blood supply to tissue, especially critical organs, so as to deliver oxygen to all cells and remove metabolic waste, via the perfusion of blood throughout the body. ∑

Airway: the protection and maintenance of a clear passageway for gases (principally oxygen and carbon dioxide) to pass between the lungs and the atmosphere. ∑

Breathing: inflation and deflation of the lungs (respiration) via the airway

These goals are codified in mnemonics such as ABC and CAB. The American Heart Association (AHA) endorses CAB in order to emphasize the primary importance of chest compressions in cardiopulmonary resuscitation.

Healthy people maintain the CABs by themselves. In an emergency situation, due to illness (medical emergency) or trauma, BLS helps the patient ensure his or her own CABs, or assists in maintaining for the patient who is unable to do so.

For airways, this will include manually opening the patients airway (Head tilt/Chin lift or jaw thrust) or possible insertion of oral (Oropharyngeal airway) or nasal (Nasopharyngeal airway) adjuncts, to keep the airway unblocked (patent).

For breathing, this may include artificial respiration, often assisted by emergency oxygen.

For circulation, this may include bleeding control or cardiopulmonary resuscitation (CPR) techniques to manually stimulate the heart and assist its pumping action.

TRAUMA DEFINITION

The longer we live, the more inevitable it is that we will experience trauma.

Trauma is the response to a deeply distressing or disturbing event that overwhelms an individual's ability to cope, causes feelings of helplessness, diminishes their sense of self and their ability to feel the full range of emotions and experiences.

POLYTRAUMA

Polytrauma (multitrauma) is a short verbal equivalent used for severely injured patients usually with associated injury (i.e. two or more severe injuries in at least two areas of the body), less often with a multiple injury (i.e. two or more severe injuries in one body area).

An important condition for the use of the term polytrauma is the incidence of the traumatic shock and/or hemorrhagichypotensis and a serious endangering of one or more vital functions of the organism.

At least one out of two or more injuries or the sum total of all injuries endangers the life of the injured person with polytrauma. For its variable and non-homogeneous content the term polytrauma cannot be used as a final diagnosis without an objective quantification of the extent of the severity of the injury.

Therefore recommends to use this term to express a severe injury endangering the life as a general term which must be necessarily specified by the actual morphological and functional diagnoses. The term "polytraumatism" used in practice is not exactly a synonym of polytrauma, however, it has a direct generalizing relation to it.

Polytraumatism embraces the broad health care and general societal problem area relating to severe associated and multiple injuries (i.e. to polytrauma).

the actual classification of polytraumas according to their severity into four, three or two groups. This classification is based on the principles of general quantification of the severity of the injury (from the viewpoint of individual injuries and at the same time from the viewpoint of all concurrent injuries) divided into five or six grades.

PRE-HOSPITAL CARE

1.1. Airway management

1.1.1 Consider using a supraglottic device*

if the patient's airway reflexes are absent. Use basic airway manoeuvres like inserting a Guedel's airway**

bag and mask ventilation if required or if supraglottic device placement is not possible.

*supraglottic device - Laryngeal mask airway, proseal, i-gel etc. **Guedels airway = Oropharyngeal airway/oral airway

1.2 Chest Trauma

1.2.1 Use clinical assessment to diagnose pneumothorax for the purpose of triage or intervention

1.2.2 In patients with an open pneumothorax: Cover the open pneumothorax with a three sided occlusive dressing and Observe for the development of a tension pneumothorax

1.3 Haemorrhage

1.3.1 Use simple dressings (sterile gauze pads) with direct pressure to control external haemorrhage.

1.3.2 In patients with major limb trauma use a tourniquet* if direct pressure has failed to control life threatening haemorrhage. (*Tourniquet can be a bandage roll, rubber tubing , crepe bandage etc.)

1.3.3 If active bleeding is suspected from a pelvic fracture after blunt high-energy trauma: Apply a pelvic binder

1.3.4 Use intravenous tranexamic acid as soon as possible in patients with major trauma and active or suspected active bleeding. (*Dose of Tranexamic acid - 1 gmi.v. over 10 min followed by 1 gmI.v. over 8 hrs)

1.3.5 Do not use intravenous tranexamic acid more than 3 hours after injury in patients with major trauma

1.3.6 For circulatory access in patients with major trauma in pre-hospital settings: Use peripheral intravenous access.

1.3.7 In pre-hospital settings, titrate volume resuscitation to maintain a palpable central pulse(carotid or femoral).

1.3.8 In pre-hospital settings only use crystalloids (Ringer’s lactate or Normal saline) to replace fluid volume in patients with active bleeding

1.3.9 Minimise ongoing heat loss in patients with major trauma. *Blankets can be used for reducing heat loss

1.4 Pain Management

1.4.1 Assess pain regularly in patients with major trauma using a pain assessment scale

1.4.2 For patients with major trauma, use intravenous morphine/strong opioids as the first line analgesic and adjust the dose as needed to achieve adequate pain relief *

1.5 Spine Trauma

1.5.1 Carry out full in-line* spinal immobilisation

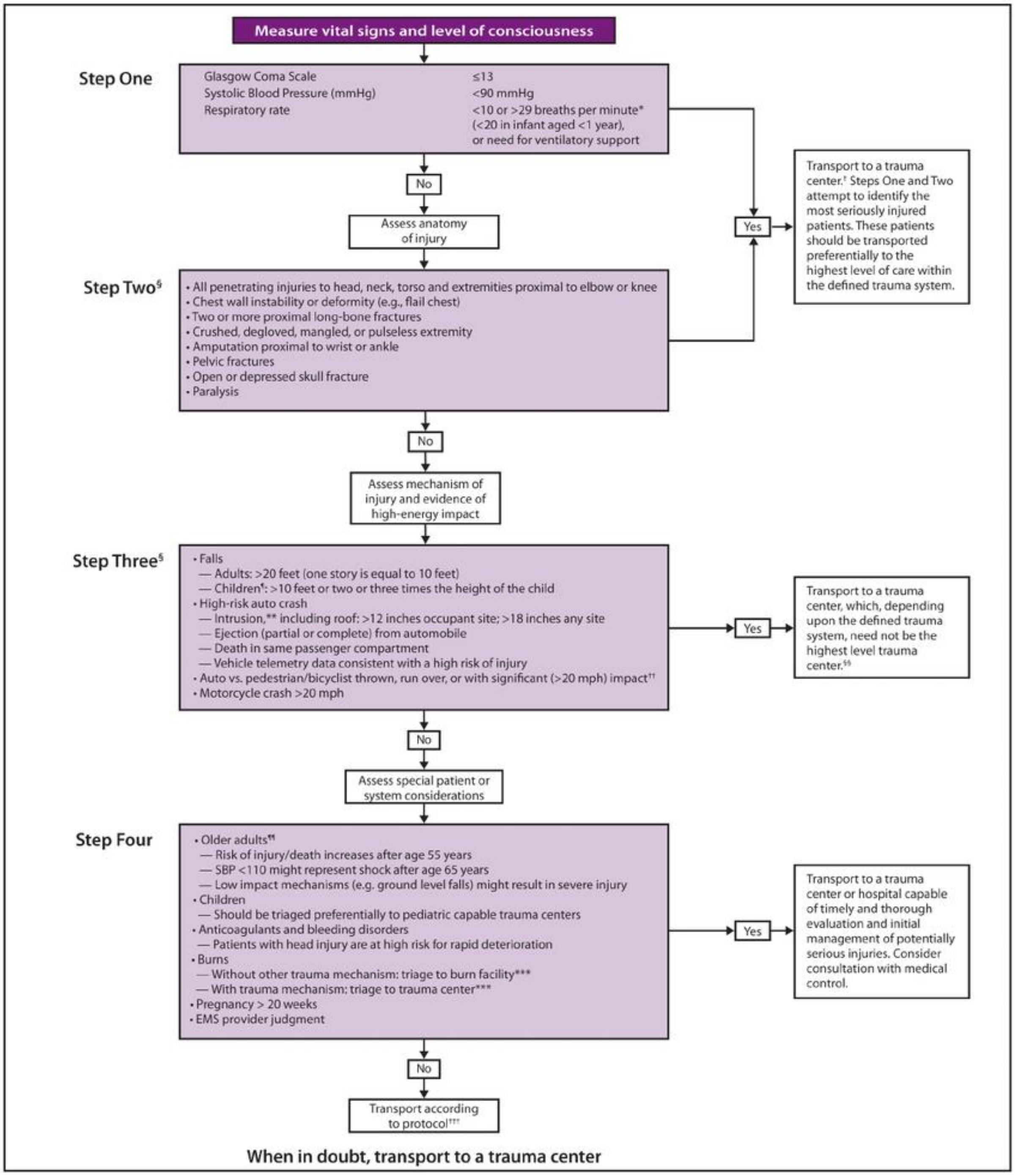
*By placing two blocks on either side of the head. Intravenous fluid bottles can also be used to prevent movement.

1.6 Fractures

1.6.1 Do not irrigate open fractures of the long bones, hindfoot or midfoot in pre-hospital settings

1.6.2 Consider a saline soaked dressing covered with an occlusive layer for open fractures in prehospital settings.

1.6.3 In the pre-hospital setting, consider the following for people with suspected long bone fractures of the legs: A rigid or malleable splint or adjacent leg as a splint if the suspected fracture is above the knee



2011 Field Triage Guideline Recommendations

Modifications to the previously published Guidelines (*1*) have been summarized (Box 2). The sections that follow discuss the changes made and provide the rationale of the Panel for making these changes.

The 2011 Guidelines have been endorsed by multiple professional organizations and federal government agencies. [¶] The national Highway Traffic Safety Administration concurs with these Guidelines. An updated list of endorsing organizations is available at http://www.cdc.gov/fieldtriage.

Name of the Guidelines

The name of the Guidelines remains unchanged. The Panel recognized that many different names have been attached to the Guidelines, creating potential confusion for persons, communities, and states attempting to implement the Guidelines. In addition, the Panel reviewed feedback that indicated that confusion exists as to whether this represents mass casualty triage or "routine" daily triage of injured patients. The Guidelines apply to "routine" daily triage of injured patients. After deliberations, the Panel decided not to change or modify the name of the decision scheme because creating a new and different name would likely only add to or increase any confusion or misunderstanding that exists, many states and locales have begun implementation of the decision scheme based on its name as given and to change it at this point might unduly burden those systems; and even if a new name was added, end-users might attach a different name to it, and the problem would remain unresolved. The Panel recommended that CDC continue to provide educational materials that describe the purpose of the Guidelines and that the decision scheme be called either the "field triage decision scheme" or the "guidelines for field triage of injured patients." The Panel also recommended that the Guidelines not be referred to as a "national protocol" because using the term "protocol" has an unintended proscriptive inference for the end-user that could restrict local adaptation required for optimal implementation.

Step One: Physiologic Criteria

In Step One, the Glasgow Coma Scale, and Respiratory Rate criteria were modified. Step One is intended to allow for rapid identification of critically injured patients by assessing level of consciousness (Glasgow Coma Scale [GCS]) and measuring vital signs (systolic blood pressure [SBP] and respiratory rate). Vital sign criteria have been used since the 1987 version of the ACS Field Triage Decision Protocol (*8*). These criteria demonstrate high predictive value for severe injury. Of 289 references identified from the structured literature review, 82 (28%) were relevant to Step One. SBP <90 and respiratory rate <10 or >29 remain significant predictors of severe injury and the need for a high level of trauma care. Multiple peer-reviewed articles published since 2006 support this threshold (*25*–*28*).

The Panel recommended transport to a facility that provides the highest level of care within the defined trauma system if any of the following are identified:

- Glasgow Coma Scale ≤13, or
- SBP of <90 mmHg, or
- respiratory rate of <10 or >29 breaths per minute (<20 in infant aged <1 year), or need for ventilatory support.

Glasgow Coma Scale: Criterion Clarified

Experience with the 2006 Guidelines has indicated that many readers and end-users perceived that the criterion of GCS <14 recommended taking patients with a GCS of ≤14 to trauma centers. To reduce any future confusion, the Panel voted unanimously to rewrite the criterion as GCS ≤13.

Need for Ventilatory Support: Criterion Added

The need for ventilatory support (including both bag-mask ventilation and intubation) was added to "respiratory rate of <10 or >29 breaths per minute (<20 in an infant aged <1 year). Although it has been assumed that patients requiring ventilatory support would meet the respiratory rate criterion, three studies suggest that this is not necessarily the case and demonstrate the importance of considering ventilatory support, in addition to respiratory rate, in identifying seriously injured patients. Among 6,259 adults meeting Step One criteria across 11 sites in North America, an advanced airway attempt (i.e., intubation or supraglottic airway placement) was the strongest predictor of death or prolonged hospital stay among all physiologic measures **(***29*). Among 955 injured children meeting Step One criteria from the same sites, little difference was reported in the proportion of children with abnormal respiratory rates who were seriously injured compared with those whose injuries were not serious (44% and 47%, respectively); however, the need for ventilatory assistance was highly discriminating between the two groups (46% and 3%, respectively) and again was determined to be the strongest physiologic predictor of serious injury (*30*). Another study involving 3,877 injured children had similar findings, with field intubation attempt being second only to GCS in identifying children in need of trauma center care (*31*). Therefore, after reviewing the literature and considering the evidence, the Panel added "or need for ventilatory support" to the respiratory rate criterion, recognizing that adults and children requiring advanced airway interventions represent a very high-risk group, whether or not other physiologic abnormalities (including specific respiratory rate values) are present and to ensure that patients requiring airway support receive the highest level of trauma care within the defined trauma system.

Additional Physiologic Concerns Discussed by the Expert Panel

The following sections describe additional physiologic criteria topics that were discussed by the Panel and for which no changes were recommended.

Glasgow Coma Scale Motor

Although the Panel considered adding the motor portion of the Glasgow Coma Score (GCS_m) as an alternative to the GCS total (GCS_t), which includes verbal, eye opening, and motor components, no change was made. The motor score has been demonstrated to be associated with the need for lifesaving interventions (*32,33*). Debate occurred as to whether using only the motor score would be easier for EMS personnel than the GCS_t; however, because of the lack of confirmatory evidence, the long standing use of the GCS_t and its familiarity among current EMS practitioners, the inclusion of the motor score within the GCS_t, and complications because of the difficulty of comparative scoring systems, the Panel recommended no change at this time.

Systolic Blood Pressure in Older Adults and Children

The Panel discussed including a systolic blood pressure (SBP) threshold of <110 for patients aged >65 years. After deliberation, the Panel decided to account for physiologic differences in older adults in Step Four under "Older Adults"; the rationale and clinical evidence are discussed in that section. The Panel maintained the decision to retain the SBP<90mmHg threshold in children. Because of the substantial proportion of young children with no field measurement of blood pressure (*31*), the Panel believed this decision would have minimal impact on overtriage.

Shock Index

A retrospective chart review of 2,445 patients admitted over a 5-year period at an urban Level I trauma center determined that shock index (heart rate divided by systolic blood pressure) is an accurate prehospital predictor of mortality (*34*). However, the Panel identified no evidence to suggest that shock index improves field identification of seriously injured patients beyond the existing physiologic measures, and noted that utilization of the shock index requires a calculation in the field, and its value during field triage remains unclear. The Panel noted that the use of shock index for triage decisions might be more applicable in the future as vital signs and triage criteria become routinely recorded and collected on mobile devices

Step Two: Anatomic Criteria

In Step Two, the criteria pertaining to chest and extremity injuries were modified. Step Two of the Guidelines recognizes that certain patients, on initial presentation to EMS providers, have normal physiology but have an anatomic injury that might require the highest level of care within the defined trauma system. Of the 289 references identified from the structured literature review, 57 (20%) were relevant to Step Two. Most of the literature supported Step Two of the 2006 Guidelines, and the majority of Step Two criteria therefore remain unchanged.

The Panel recommended transport to a facility that provides the highest level of care within the defined trauma system if any of the following are identified:

- all penetrating injuries to head, neck, torso, and extremities proximal to elbow or knee;
- chest wall instability or deformity (e.g. flail chest);
- two or more proximal long-bone fractures;
- rushed, degloved, mangled, or pulseless extremity;
- amputation proximal to wrist or ankle;
- pelvic fractures;
- open or depressed skull fractures; or
- paralysis.

Crushed, Degloved, Mangled, or Pulseless Extremity: Criterion Modified

This criterion was modified to include "pulseless" extremities. Several published articles highlighted vascular injury as an important injury requiring specialized care (*35–40*). In a retrospective analysis of

73 patients with arterial injuries, 37 patients (51%) had associated injuries (e.g., bone and nerve), and five patients (7%) required amputation (*37*). In a 5-year retrospective review of 52 patients with upper extremity vascular injury, 41 patients (79%) had associated nerve or bone injury, 14 patients (27%) required fasciotomies, and seven patients (13%) required amputation. In addition, the patients in this study were severely injured, with a mean ISS of 17.52 (*40*). After review of the evidence, the Panel decided to add "pulseless" to the criterion for crushed, degloved, or mangled extremity because vascular injury of the extremity might lead to significant morbidity and mortality, require a high level of specialized trauma care involving multiple medical specialties, and be present in the absence of a crushed, degloved, or mangled extremity (*37*).

Chest Wall Instability or Deformity (e.g., Flail Chest): Criterion Modified

This criterion was modified to read "Chest wall instability or deformity (e.g., flail chest)." The Panel identified no new evidence that specifically addressed the field triage of patients with flail chest. The Panel recognized that the field diagnosis of a flail chest is rare and that this criterion might be overly restrictive. In a 5-year retrospective study of the Israel National Trauma Registry, flail chest was identified in 262 (0.002%) of 118,211 patients and in only 262 (0.02%) of 11,966 chest injuries (*41*). Flail chest occurs in approximately 75 (0.002%) per 50,000 patients (*42*). In this context, the Panel thought that as written, "flail chest" might fail to identify all of the chest injuries that require that the patient be transported to a facility that provides the highest level of care within the defined trauma system. The Panel decided that the criterion should be changed to "chest wall instability or deformity (e.g., flail chest)" because "flail chest" rarely is diagnosed by EMS providers; the terminology "chest wall instability or deformity" more accurately describes what EMS providers are asked to identify in the field environment, and the broader terminology ensures that additional blunt trauma to the chest (e.g., multiple rib fractures) will be identified and the patient transported to the appropriate facility.

All Penetrating Injuries to Head, Neck, Torso, and Extremities Proximal to Elbow or Knee: Criterion Modified

This criterion was modified to read "elbow or knee." During its discussions, the Panel noted that penetrating injuries to the extremities proximal to the elbow or knee might signify severe injuries requiring surgical intervention or intensive care unit (ICU) admission. Therefore, the Panel modified the wording of this criterion from "elbow and knee" to "elbow or knee" to recognize that these types of injuries generally occur separately and that each can represent a severe injury.

Amputation Proximal to Wrist or Ankle: Criterion Modified

This criterion was modified to read "wrist or ankle." During its discussions, the Panel noted that amputations proximal to the wrist or ankle might signify severe injuries requiring the patient to be taken to an operating theater or admitted to an ICU. Therefore, the Panel modified the wording of this criterion from "wrist and ankle" to "wrist or ankle" to recognize that these types of injuries most commonly occur separately and that each can represent a severe injury.

Additional Anatomic Concerns Reviewed by the Panel

The following sections describe additional anatomic criteria topics that were discussed by the Panel and for which no changes were recommended.

Tourniquet Use

Successful medical treatment of soldiers on the battlefield prompted researchers to explore the potential use of tourniquets for the rapid treatment of vascular injuries seen in the civilian population. Recent battlefield experiences indicate that tourniquet use reduces mortality by limiting exsanguinations (*43,44*). A retrospective review of 75,000 trauma visits at two Level 1 trauma centers in Texas identified 14 patients with penetrating extremity injuries who arrived at the hospital dead, required emergency thoracotomy, or underwent cardiopulmonary resuscitation. Eight decedents (57%) were identified as having extremity injuries that might have been amenable to application of a tourniquet in the prehospital environment (*45*).

After review of the literature and subsequent discussion, the Panel elected not to include tourniquet use as an independent Step Two criteria because evidence is limited regarding the use of tourniquets in the civilian population; use of tourniquets among EMS systems varies; inclusion of tourniquet use as a criterion could lead to overuse of tourniquets instead of basic hemorrhage control methods and thus potentially result in overtriage; and the "crushed, degloved, mangled, or pulseless extremity," "all penetrating injuries to head, neck, torso, and extremities proximal to elbow or knee," and "amputation proximal to wrist or ankle" criteria were as likely to identify severely injured patients regardless of tourniquet use. The Panel recommended further study of the use of this intervention.

Pelvic Fractures

Patients with pelvic fractures should receive rapid and specialized care because of the possibility of internal hemorrhage and other associated injuries. The Panel discussed whether the term "pelvic fracture" was the most appropriate term for the Guidelines to use to aid EMS professionals in identifying patients in need of trauma center care, recognizing that certain states and communities have changed this terminology to read "unstable pelvic fracture," "suspected pelvic fracture," or "pelvic instability." After extensive discussion, the Panel decided to retain the term "pelvic fractures" as written because no compelling evidence exists that a different name would identify the patients in need of trauma center care more accurately, for the sake of simplicity, and because adding "suspected" or "tenderness" to this criterion might increase overtriage unnecessarily.

Step Three: Mechanism of Injury

In Step Three, the intrusion criterion was modified to include roof intrusion. An injured patient who does not meet Step One or Step Two criteria should be evaluated in terms of mechanism of injury (MOI) to determine if the injury might be severe but occult. Evaluation of MOI will help to determine if the patient should be transported to a trauma center. Although different outcomes have been used, recent studies have demonstrated the usefulness of MOI for field triage decisions. A retrospective study of approximately 1 million trauma patients indicated that using physiologic and anatomic criteria alone for triage of patients resulted in undertriage, implying that using MOI for determining trauma center need helped reduce the problem of undertriage (*46*). Another study of approximately one half million patients determined that MOI was an independent predictor of mortality and functional impairment of blunt trauma patients (*47*). Among 89,441 injured patients evaluated by EMS providers at six sites, physiologic and anatomic criteria identified only 2,600 (45.5%) of 5,720 patients with an ISS >15, whereas MOI criteria identified an additional 1,449 (25.3%) seriously injured patients with a modest (10%) incremental increase in overtriage (from 14.0% to 25.3%) (*48*).

Of the 289 references identified from the structured literature review, 85 (29%) were relevant to Step Three. Articles that were considered to provide either compelling evidence for change to the Guidelines or articles that provided insight into specific mechanisms are discussed below.

The Panel recommended transport to a trauma center if any of the following are identified:

- falls
    - adults: >20 feet (one story = 10 feet)
    - children: >10 feet or two to three times the height of the child
- high-risk auto crash
    - intrusion, including roof: >12 inches occupant site; >18 inches any site
    - ejection (partial or complete) from automobile
    - death in same passenger compartment
    - vehicle telemetry data consistent with a high risk for injury;
- automobile versus pedestrian/bicyclist thrown, run over, or with significant (>20 mph) impact; or
- motorcycle crash >20 mph

High-Risk Automobile Crash: Intrusion, Including Roof >12 Inches to the Occupant Site; >18 Inches to Any Site: Criterion Modified

This criterion was modified to include roof intrusion. In a study of 880 children ≤15 years, intrusion, independent of other factors such as age, restraint use, seating row and direction of impact was a significant and strong predictor of a severe injury measured by an Abbreviated Injury Scores (AIS) >2 or >3. Furthermore, these analyses demonstrated that each additional centimeter of intrusion increased the odds of an AIS >2 or >3 by 2.9% (*49*). Another study identified similar results indicating that drivers whose vehicles suffered side impact collisions had nearly four times (OR = 3.81; 95% CI = 1.26–11.5) the odds of suffering an AIS >3 or have severe head injury compared with drivers whose vehicles had different collision characteristics; these results further suggested that drivers who had intrusion into the passenger compartment at the driver's position were significantly more likely to have severe injury regardless of damage distribution across the frontal plane of the vehicle (*50*).

Data from CIREN and NASS-CDS suggest that intrusion of >12 inches at an occupant site or intrusion of >18 inches at any site is a significant predictor of severe injury requiring trauma care. These data also indicate that roof intrusion is predictive of the need for trauma care (*51*).

After deliberations, the Panel decided to add "including roof" to the intrusion category because the 2006 guidelines did not convey clearly that vertical roof intrusion has the same implication for increased injury severity as horizontal intrusion into the vehicle occupant space, and a review of the literature confirms that intrusion, including vertical roof intrusion, is an important predictor of trauma center need.

Additional Mechanism-of-Injury Concerns Discussed by the Panel

The following sections describe additional MOI criteria topics that were discussed by the Panel and for which no changes were recommended.

Extrication

Prolonged extrication has been reported to be an independent predictor (OR = 2.3; 95% CI = 1.2–4.6) of emergency surgery need in hypotensive (SBP <90 mmHg) trauma patients (*52*). An earlier Australian study, reviewed by the Panel in 2005, determined that prolonged extrication time was associated with major injury (*53*). However, neither of these studies used ISS >15 as a threshold, nor did they examine whether prolonged extrication was an independent predictor of serious injury after Steps 1 and 2. During the 2006 revision, the Panel considered poor standardization in the literature regarding the definition of extrication time as well as its dependence on local resources, scene conditions, and extrication expertise in its decision to eliminate prolonged extrication. The Panel concluded at that time that the vehicle intrusion criterion should be an adequate surrogate for prolonged extrication. During this latest revision, examination of CIREN data confirmed that the current intrusion criterion was more specific for ISS >15 injury than need for physical extrication of the vehicle occupant (length of extrication unknown) (*51*).

Recent data collected over a 2-year period from 11,892 interviews with EMS personnel regarding transport of injured patients to a regional trauma center indicated that of the 9,483 patients who did not meet the anatomic or physiologic criteria, extrication time >20 minutes (as estimated by the EMS provider) suggested that occupants of motor-vehicle crashes had a significantly greater likelihood of being admitted to an ICU, needing nonorthopedic surgery in the first 24 hours after injury, or dying (sensitivity: 11%; specificity: 98%; positive likelihood ratio: 5.0) (*54*).

Although these data would appear to support the inclusion of "prolonged extrication time" as a mechanism criterion for identifying a major trauma patient, the Panel concluded that this was not an independent predictor in that the intrusion criterion addressed this mechanism event adequately, and the imprecise nature of this data was difficult to interpret reliably and include. The Panel concluded that no compelling evidence exists to reinstitute prolonged extrication time as a criterion in MOI.

Rollover

Rollover vehicle crash events are less common than planar crashes of vehicles into other vehicles or fixed objects, but they are more dangerous overall (*51,55*). In 2004, NHTSA reported 11,728,411 motor-vehicle crashes. Of these, the 275,637 (2.4%) rollover crashes were associated with one third of all occupant deaths (*56,57*). Two recent studies highlight the importance of rollover as a predictor of severe injury (*49,57*). However, both studies were limited because they did not control for Step One and Step Two criteria when determining the need for transport to a trauma center. A study was conducted that used 11,892 EMS provider interviews regarding transport of injured patients to identify injured patients who did not meet the physiologic or anatomic criteria to determine if rollover was a predictor of trauma center need. A total of 523 rollover cases occurred, and the sensitivity for trauma center need (defined as death, admission to ICU, or nonorthopedic surgery within 24 hours of arrival) was 13% (range: 8.2%–18.0%) and the specificity was 87% (range: 86.2%–88.3%). When the data were analyzed by the number of quarter turns, only minimal improvement in positive likelihood ratios was reported, and none was >1.7 (*54*).

The Panel reexamined other data from rollover crashes to determine whether subsets of rollover crashes might warrant inclusion as a criterion in MOI. NASS-CDS rollover crash data were analyzed to determine the effect of the number of quarter turns, the final position of the vehicle, the extent of roof intrusion as well as partial and full ejection of the occupant from the vehicle. Rollover crashes with roof intrusion of 24 inches were associated with a 19.3% risk of ISS >15 injury. Any ejection (partial or full) was associated with a 21.5% risk of ISS >15 injury, and complete occupant ejection was associated with a 27.4% risk of ISS >15 injury (*51*).

The Panel thought that the existing ejection and intrusion criterion, and the previously discussed modification to include roof intrusion, adequately addressed field triage of this subset of severe rollover crashes. The Panel concluded that rollover event, as a standalone criterion, has <9% PPV for ISS >9 and is insufficient to meet the 20% PPV for ISS >15 targeted as a threshold for inclusion in Step Three.

As a crash mechanism, rollover might result in one or more occupants sustaining severe injuries. The Panel reiterated its opinion that patients involved in rollover crashes should be evaluated by EMS personnel to determine if they have injuries that meet Step One, Step Two, or other Step Three criteria. Patients involved in rollover crashes who meet Step One or Step Two criteria should be transported preferentially to the highest level of care within the defined trauma system. Patients involved in rollover crashes who meet only Step Three (but not Step One or Step Two) criteria should be transported to a trauma center that, depending on the defined trauma system, need not be the highest-level trauma center. The Panel noted that the increased injury severity associated with rollover crashes results from an occupant being ejected either partially or completely from the vehicle, and partial or complete ejection is already a criterion for transport to a trauma center. Therefore, the previous decision to remove rollover from the 2006 Guidelines was reaffirmed, and no changes were made regarding rollover. In addition, the Panel noted that adding "including roof" under the intrusion criterion will identify rollover crashes with significant roof intrusion.

Vehicle Telemetry

Several studies have indicated that mechanical aspects of collisions can be predictors of injury in motor vehicle crashes. A study that used 10 years of NASS-CDS data determined that seat belt use, direction of impact, and Delta V (i.e., a change in velocity) were the most important predictors of an ISS >15 (*58*). The study also concluded that an event data recorder (EDR) system could provide emergency personnel with good estimates of injury status based solely on data such as seat belt use, direction of impact, and Delta V, which can be collected from the vehicle. Other research has suggested that factors that can be recorded by a vehicle EDR system such as Delta V (*59,60*), high speed velocity (*61*), location of impact (*62*), and vehicle weight and type (*63*) are predictors of severe injury. The Panel recognized the increasing availability of vehicle telemetry in newer vehicles and reaffirmed its position that vehicle telemetry might have an important role in the triage of injured patients as the crash technology, data transmission, and telemetry availability continue to expand. An explanation of how vehicle telematics could be used in field triage has been published previously (*64*).

Falls

Research conducted on falls is limited because of the inability to study the impact of measured fall height directly. However, three studies were identified that added insight into this mechanism. One study of 63 cases of falls indicated that among children aged <2 years, height of fall >2 meters (>6.6 feet) is a predictor of injury (*65*). A similar study of 72 children aged 4 months–5 years indicated that falls from <1 meter (3.3 feet) could cause a skull fracture if the fall occurred on a hard surface (*66*). Furthermore, another study conducted in France of 287 victims of falls from height indicated that height of fall, hard impact surface, and having the head being the first body part to touch the ground were independent predictors of mortality (*67*). On the basis of these three studies with limited sample sizes and the overall limited data on falls, no changes were made to this section.

Step Four: Special Considerations

In Step Four, the criteria for older adults and anticoagulation were modified, and the criteria for end stage renal disease requiring dialysis and time-sensitive extremity injury were removed. In Step Four, EMS personnel must determine whether persons who have not met physiologic, anatomic, or mechanism steps have underlying conditions or comorbid factors that place them at higher risk of injury or that aid in identifying the seriously injured patient. Persons who meet Step Four criteria might require trauma center care. A retrospective study of approximately 1 million trauma patients indicated that using physiologic (Step One) and anatomic (Step Two) criteria alone for triage of patients resulted in a high degree of under triage, implying that using special considerations for determining trauma center need helped reduce the problem of under triage (*46*). Among 89,441 injured patients evaluated by EMS providers at six sites, physiologic, anatomic, and mechanism of injury criteria identified 4,049 (70.8%) patients with an ISS >15; Step Four of the Guidelines identified another 956 (16.7%) of seriously injured patients, with increase in overtriage from 25.3% to 37.3%. (*48*).

Of the 289 references identified from the structured literature review, 77 (27%) were relevant to Step Four. No changes were made to the Step Four criteria for burns, pregnancy, and EMS provider judgment. The Panel recommended transport to a trauma center or hospital capable of timely and thorough evaluation and initial management of potentially serious injuries for patients who meet the following criteria:

- older adults
  - risk for injury/death increases after age 55 years
  - SBP <110 might represent shock after age 65 years

    - low impact mechanisms (e.g., ground-level falls) might result in severe injury
- children
    - should be triaged preferentially to pediatric capable trauma centers
- anticoagulants and bleeding disorders
    - patients with head injury are at high risk for rapid deterioration
- burns
    - without other trauma mechanism: triage to burn facility
    - with trauma mechanism: triage to trauma center
- pregnancy >20 weeks
- EMS provider judgment

Older Adults: Criterion Modified

This criterion was modified to include statements that recognize that a SBP <110 might represent shock after age 65 years and that low-impact mechanisms (e.g., ground-level falls) might result in severe injury. The Panel recognized that adults aged >65 years are not transported consistently to the hospital best equipped to manage their injuries (high rates of undertriage relative to other age groups). A retrospective analysis of 10 years of prospectively collected data in the Maryland Ambulance Information System identified a higher undertriage rate for patients aged ≥65 years compared with those aged <65 years (49.9% and 17.8%, respectively; $p<0.001$) (*68*). On subsequent multivariate analysis, the authors noted a decrease in transport to trauma centers for older patients beginning at age 50 years (OR = 0.67; 95% CI = 0.57–0.77), with a second decrease at age 70 years (OR = 0.45; 95% CI = 0.39–0.53) compared with those patients aged <50 years. In a 4-year retrospective study of 13,820 patients in the Washington State Trauma Registry, those patients aged >65 years were less likely than those aged ≤65 years to have had the prehospital system or the trauma team activated. In addition, use of multivariate logistic regression indicated that physiologic triage variables (e.g., blood pressure and heart rate) were unreliable predictors of mortality or interventions in the hospital (*69*).

Several studies suggest that differences in the physiologic response to injury and high-risk mechanisms in older adults might partly explain undertriage rates in this age group. In a retrospective chart review of 2,194 geriatric patients (aged ≥65 years) at a Level 1 trauma center, mortality was noted to increase at a SBP of <110 mmHg (*70*). A retrospective review of 106 patients aged >65 years at a Level II trauma center indicated that occult hypotension (i.e., decreased perfusion that is not evident by standard vital sign criteria) was present in 42% of patients with "normal" vital signs (*71*).

In addition, the Panel reviewed literature that indicated that older adults might be severely injured in low-energy events (e.g., ground-level falls). An analysis of deaths reported by the King County Medical Examiner's Office (King County, Washington) indicated that ground level falls accounted for 237 (34.6%) of all deaths (684) in patients aged ≥65 years (*72*). A study of 57,302 patients with ground-level falls demonstrated higher rates of intracranial injury and in-hospital mortality among adults aged ≥70 years (*73*).

On the basis of its review, the Panel elected to strengthen the criterion regarding older adults in Step Four. "SBP <110 might represent shock after age 65" and "low-impact mechanisms (e.g., ground-level falls) might result in severe injury" were added under "Older Adults" in Step Four because undertriage of the older adult population is a substantial problem, the evidence reviewed suggests that the physiologic parameters used in younger patients might not apply to older adults, occult injury is likely to be greater among older adults, low-energy transfers (e.g., ground-level falls) might result in serious injuries in this population, and field identification of serious injury among older adults must be more proactive.

Anticoagulation and Bleeding Disorders: Patients with Head Injury Are at High Risk for Rapid Deterioration: Criterion Modified

The Panel modified this criterion to highlight the potential for rapid deterioration in anticoagulated patients with head injuries. Anticoagulation use has been associated with an increased risk for intracranial hemorrhage following head injury (*72,73–77*) and longer hospital stays (*72,78*). A retrospective review of 141 Level II trauma center patients who were taking warfarin or clopidogrel, had minor head injuries, and had a GCS of 15 indicated that 41 (29%) had intracranial hemorrhage (*74*). A study of 237 patients who died following ground-level falls indicated that 71 (30%) patients were anticoagulated with aspirin, warfarin, clopidogrel, heparin, or multiple anticoagulants (*72*). Preinjury use of warfarin has been associated with higher mortality among adults aged >65 years with mild head injuries using a GCS measure of 14 or 15 (*74*). In a retrospective, case-controlled study of 131 patients with traumatic intracranial hemorrhage who were taking aspirin, clopidogrel, or warfarin before they were injured, anticoagulated patients taking clopidogrel had higher mortality rates (OR = 14.7; 95% CI = 2.3–93.6) and were more likely to be discharged to a long-term facility (OR = 3.25; 95% CI = 1.06–9.96) (*78*).

After reviewing this literature, the Panel elected to strengthen this criterion, underscoring the potential for anticoagulated patients who do not meet Step One, Step Two, or Step Three criteria but who have evidence of head injury to undergo rapid decompensation and deterioration. The panel recognized that patients who meet this criterion should be transported preferentially to a hospital capable of rapid evaluation and imaging of these patients and initiation of reversal of anticoagulation if necessary.

End-Stage Renal Disease Requiring Dialysis: Criterion Removed

The panel reviewed this specific criterion, which was added to the 2006 Guidelines because of the potential risk of anticoagulation in these patients and the need for special resources (e.g., dialysis) to be used in this patient population. However, in 2011, the Panel elected to remove this criterion, noting that research demonstrating the value of dialysis as a triage criterion for identifying patients with serious injury is lacking and that concerns regarding anticoagulation in this population are addressed under the anticoagulation and bleeding disorders criterion. The Panel thought that transport decisions regarding patients requiring dialysis are best made in consultation with medical control or based on local transport protocols for such patients.

Time-Sensitive Extremity Injury: Criterion Removed

With the addition of "pulseless" to Step Two criteria, the panel thought this criterion was redundant, and removed it from the 2011 Guidelines.

Transition Boxes and Flow of the 2011 Schematic: Format Modified

The transition boxes in the schematic (Figures 1 and 2) provide destination guidance to the prehospital provider for patients meeting criteria outlined in the preceding Step. After reviewing input from providers, states, and local EMS agencies, the Panel recognized the need to simplify the appearance of the Guidelines, modify the transition boxes, clarify the intent of the Guidelines, and simplify communication of action steps in the Guidelines across a variety of providers and systems. To do this, the Panel took action both to improve the layout of the decision scheme and to modify specific wording within the boxes. To improve the layout of the transition boxes, the Panel took two steps. First, because the transition boxes between Step One and Step Two communicate the exact same information and thus were thought to be redundant, they were consolidated into one box. Second, all action steps were moved to the right side of the page for easier readability and determination of outputs for patients meeting different steps in the Guideline (Figure 2).

Next, the Panel modified the language within the boxes to ensure consistency between transitions in the Guideline. The first word in all transition boxes was changed to "transport" to ensure consistency between all boxes. Next, to emphasize the need for state, regional, and local trauma systems to define the parameters of their trauma systems (including the "highest level of care"), the word "defined" was added in front of "trauma system" for transition boxes following Steps One, Two, and Three. This change recognizes that the highest level of trauma care should be determined by the regional/state trauma system design and authority. In most systems, this is a Level I center, but in given circumstances, the highest level of care available might be a Level II, III, or IV facility or a local, critical access hospital serving the region. Third, in the transition box following Step Three, the words "closest appropriate'' were removed. This change, with the addition of "defined" as above, makes this transition box consistent with the wording in the remainder of the Guidelines. Finally, regarding the transition box following Step Four in the 2006 Guidelines, the Panel recognized that many EMS systems operate via indirect (off-line) medical control (using medical director–approved protocols in a sanctioned, algorithmic process) and not direct (online) medical control (in which direct communication can take place between a physician and an EMS provider via radio or telephone for a specific patient interaction). Therefore, the Panel removed mandatory contact with medical control and emphasized that online control with verbal consultation might be appropriate. The wording of this box also was modified to emphasize that these patients need to go to a facility at which they can be evaluated readily with appropriate initial management for injury, whether or not this is a trauma center.

Future Research for Field Triage

The Panel noted an increase in the peer-reviewed published literature regarding field triage from the 2006 Guideline to this current revision. The current revision process identified and reviewed 289 articles during 2006–2011 (~48 articles/year) directly relevant to field triage, 24 times the annual number of articles during 1966–2005 (~2/year) cited in the 2006 Guidelines (*1*). Despite this increase in the number of articles, the Panel concluded that ensuring that the Guidelines are based on the best clinical evidence requires expanded surveillance (Box 3), focused research using robust study designs, and consistent outcome measures. The preponderance of existing triage studies reviewed by the Panel used retrospective data, trauma registry samples, single EMS agencies, and single trauma centers, all of which can result in biased estimates and reduced generalizability. Prospective triage research is needed that includes multiple sites, multiple EMS agencies, trauma and nontrauma hospitals, and population-based study designs that reduce selection bias and increase the generalizability of study findings. In addition, relatively little triage literature exists that evaluates the Guidelines in their entirety (as opposed to an individual criterion or component steps of the decision scheme) and the contribution of each step to the full Guidelines. Prospective studies evaluating the full Guidelines among the broad injury population served by EMS are needed to assess the accuracy of the Guidelines appropriately and to better identify targets for improvement. Further, the process of field triage in rural settings, including the impact of geography on triage, issues regarding proximity to trauma centers, use of air medical services, integration of local hospitals for initial stabilization, and secondary triage at nontrauma hospitals, is poorly understood. As a substantive portion of the U.S. population lives >60 minutes from the closest major trauma center, and 28% of U.S. residents are only able to access specialized trauma care within this time window by helicopter (*79*), field triage in nonurban environments needs to be understood better.

Current peer-reviewed triage literature has described multiple outcome measures, including injury severity, clinical outcomes, need for trauma center resources (with or without a measure of timeliness), or a combination of these metrics. The most common clinical outcome measure is ISS >15, although the AIS ≥3 has also been used. Trauma center need has been measured by use of blood products, interventional radiology, major nonorthopedic surgery, or ICU stay. This variability in outcome measures limits comparability among studies and is not always consistent with literature identifying the subgroup of patients most likely to benefit from trauma center care. Future research should address these issues and attempt to match triage evaluation to patients most likely to benefit from trauma center care and clearly define the standard of measure.

Ongoing collaboration among local, state, and regional EMS agencies with governmental, non-governmental, academia, and public health agencies and institutions will allow the continuing analysis and evaluation of the 2011 Guidelines and its impact on the care of acutely injured patients. Statewide EMS and trauma databases provide opportunities for statewide quality improvement of field triage, research, and adaptation of the Guidelines to meet state specific circumstances. Large, nationally representative databases (e.g., the National EMS Information Systems database, the National Trauma Data Bank–National Sample Program, the Healthcare Cost and Utilization Project–National Inpatient

Sample, the National Hospital Ambulatory Medical Care Survey, and NASS-CDS) could be utilized for future triage research if advances are made to link these data files across phases of care (i.e., prehospital to in-hospital). Finally, uniform definitions of prehospital variables (including triage criteria) with a standardized data dictionary and data standards (e.g., HL7 messaging) could provide comparable data across study sites and assist with linking data files from the prehospital to the hospital setting.

Areas for Specific Research Using the 2011 Field Triage Guidelines

Several new technologies, which emerge from research in the remote noninvasive monitoring of casualties in austere environments, will likely be commercially available in the near future. Of these innovations, the noninvasive monitoring of heart rate complexity and variability (*80–83*), respiratory rate (*84*), tissue oxygenation, and point-of-care lactate testing (*85*) appear promising for future field triage, but require more research.

The GCS_m of the GCS_t is used in state triage guidelines (e.g., Colorado) and has some support in peer-reviewed literature, as noted in the preceding sections. However, additional research is needed to evaluate the use of GCS_m in the context of field triage and the practical implications of changing this Step One criterion.

Advanced automatic collision notification shows promise in improving accuracy of field triage of patients involved in motor-vehicle crashes. Further effort is required to integrate this technology into trauma and EMS systems and evaluate its effectiveness.

The issue of undertriage in older adults was viewed by the Panel as a major priority for future research. There is a need to understand the basis for undertriage in this age group and how the Guidelines might be modified to reduce this problem. Related topics include the role of age in predicting serious injury, different physiologic responses to injury among older adults, different injury-producing mechanisms in older adults, emergency and trauma care providers' attitudes and behaviors regarding triage in older adults, older adults' health-care preferences for injury care, end-of-life issues and their relevance to triage, new criteria to identify serious injury in older adults, the role of trauma centers in caring for older injured adults, and other aspects of better matching patient need with hospital capability for this population. How systems respond to patient and/or family preferences regarding hospital destinations that differ from the recommendations in these Guidelines should be explored in the context of patient's rights and the moral imperative to provide the optimal chance for improved outcomes from trauma.

Finally, the cost of trauma care, the implications of field triage on cost, and the cost-efficiency of different approaches to field triage require more research. Even after accounting for injury severity and important confounders, the cost of care is notably higher in trauma centers (*86,87*). Though the cost effectiveness of trauma center care has been demonstrated among seriously injured patients (AIS ≥ 4) (*87*), it is possible that modest shifts in overtriage might have substantial financial consequences. For example, a recent study that compared the 2006 and 1999 Guidelines identified a potential $568 million cost savings at an assumed overtriage rate of 40% (*21*). However, further studies are needed to discover new ways to maximize the efficiency and cost-effectiveness of trauma systems and ensure that patients are receiving optimal injury care while considering the importance of the research, education, and outreach mission of trauma centers.

Conclusion

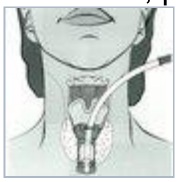
The Guidelines provided in this report are based on current medical literature, the experience of multiple states and communities working to improve field triage, and the expert opinion of the Panel members. This guidance is intended to assist EMS and trauma systems, medical directors, and providers with the information necessary to make critical decisions that have been demonstrated to increase the likelihood of improved outcomes in severely injured trauma patients (*5*).

Improved field triage of injured patients can have a profound impact on the structure, organization, and use of EMS and trauma systems, the costs associated with trauma care, and most importantly, on the lives of the millions of persons injured every year in the United States. As is noted throughout this report, improved research is needed to assess the impact of field triage on resource allocation, health-care financing and funding, and, most importantly, patient outcomes.

Primary survey (Advanced Trauma Life Support)

The management of trauma patients begins with the primary survey (also commonly referred to as Advanced Trauma Life Support, or ATLS). The primary survey consists of 5 steps (**ABCDE** approach) that are performed in order.

1. **A**irway assessment (and cervical spine stabilization)
   - If appropriately answering questions, patient has a patent airway (at least for the moment)
   - Observe patient for signs of respiratory distress
   - Inspect mouth and larynx for injury or obstruction
   - Assume cervical spine injury in blunt trauma patients until proven otherwise
   - If patient is unconscious (and therefore unable to protect their airway) or in respiratory distress, the threshold for **intubation** is very low.
     - Patients may be intubated or ventilated with the anterior portion of the cervical collar removed, or with their neck manually stabilized.
   - Patients with burn injuries; and evidence of respiratory involvement are often intubated out of precaution.

- If orotracheal intubation is difficult, perform a cricothyrotomy.
  

2. **B**reathing
   - Assess oxygenation status with pulse oximetry.
   - Inspect and auscultate chest wall for injuries.
   - In unstable patients, do not delay treatment of tension pneumothorax or hemothorax infavor of imaging.
3. **C**irculation (and hemorrhage control)
   - Assess circulatory status by palpation of central and peripheral pulses
     - Blood pressure should be measured if it can be done expediently, but it can be skipped if it would delay the rest of the primary survey.
   - Place two large-bore intravenous lines (at least 16 gauge) for blood typing and crossmatch, and resuscitation (if needed).
     - If intravenous line placement is not possible or difficult, intraosseus line should be used instead.
   - Control on-going hemorrhage with manual pressure or tourniquets.
   - Emergency thoracotomy; may be performed in patients with recent loss of pulses (especially in patients with stab wounds to the chest).
   - If patient is hypotensive, administer a bolus of intravenous saline.
     - If history of hemorrhage or on-going hemorrhage, **transfuse type O blood**.

        - If significant hemorrhage and persistent hemodynamic instability, transfuse plasma, platelets and red blood cells at 1:1:1 ratio.
    - Focused Assessment with Sonography for Trauma (FAST) exam; is usually performed, especially for hemodynamically unstable patients
        - May be performed during the secondary survey inhemodynamically stable patients
    - Some patients may require emergent reversal of anticoagulation
    - Remember hypovolemic shock due to hemorrhage requires loss of ~ 1.5 L of blood. Keep in mind the compartments where large amounts of blood may go:
        - Outside (external hemorrhage)
        - Thoracic cavity
        - Pelvic cavity
        - Abdominal cavity
        - Thighs (e.g., multiple femur fractures)
        - See Shock LC
4. **D**isability (and neurological evaluation)
    - Assess patient's Glasgow Coma Scale score
        - See Glasgow Coma Scale (GCS)
        - A **GCS score < 8** is an indication for intubation
    - Assess pupillary size

- If patient is interactive, assess motor function and light touch sensation.

5. **E**xposure (and environmental control)
   - Undress patient completely.
   - Examine body for signs of occult injury, including patient's back.
   - If patient is hypothermic, cover with warm blankets and warm intravenous fluids.
   - Palpate for vertebral tenderness and rectal tone.

References:
[1]
[2]

Diagnostic tests

The specific choice of imaging modality depends on clinical judgment and mechanism of injury; . The decision to perform any diagnostic test must be based on the patient's hemodynamic stability and must be weighed against the need for urgent transfer or operative intervention.

1. Portable x-rays
   - Typically acquired after the primary survey
   - Screening x-rays of the cervical spine, chest, and pelvis are usually performed but may be skipped if a CT-scan will be performed.
     - An exception is patients with penetrating injuries to the thorax or abdomen; , in which a chest x-ray should always be acquired even if a CT-scan will be performed.
   - Good for detection of fractures, subdiaphragmatic free air, foreign bodies, pneumothorax, hemothorax
2. Focused Assessment with Sonography for Trauma (FAST) exam
   - Typically acquired during the primary survey (especially for hemodynamically unstable patients)

- An extended version (E-FAST); may alternatively be performed, which allows for detection of pneumothorax and hemothorax.

3. CT scans
    - Typically performed after the primary survey if the patient is hemodynamically stable (otherwise the patient may decompensate inside the scanner, which could be catastrophic)
    - Ideal imaging modality given speed and high sensitivity for injury
    - In high-energy trauma (e.g., motor vehicle collisions) or severe injuries with altered mental status, a "pan scan" of the entire body is commonly performed.
4. Diagnostic peritoneal lavage (DPL): a diagnostic test used to assess for bleeding or viscus perforation in abdominal trauma. Highly sensitive, but invasive. Performed by placing a catheter into the abdomen, aspirating, then instilling a liter of warm saline. If fecal matter or significant blood are detected, this constitutes a positive test and emergent laparotomy is indicated.
    - Typically performed after the primary survey if hemoperitoneum is suspected and FAST exam is unavailable or equivocal
    - Rarely performed given the greater sensitivity of the FAST exam
5. Laboratory tests include, but are not limited to
    - CBC
    - Basic chemistries
    - Prothrombin time (given the high prevalence of patients anticoagulated on

warfarin
)

- Urinalysis
    - Gross hematuria
; should always be investigated as it may indicate urethral, bladder, or kidney injury
.
    - Microscopic hematuria
 after trauma is normal in adults, but should be investigated in pediatric populations.
- Urine pregnancy test (on all women of child-bearing age)
- Blood glucose
- Lactate
 (associated with
hypovolemic shock
)

References:
[1]
[3]

Secondary and tertiary surveys

- Secondary survey
    - Performed after the
primary survey
 has been completed and the patient is deemed stable
    - Complete history and thorough physical examination
    - Additional diagnostic tests are tailored to remaining symptoms, mechanism of injury, and patient comorbidities.
    - Main goal is to minimize the risk of missed injuries.
- Tertiary survey
    - Delayed re-examination of the patient (usually ~ 24 hours after admission)
    - Main goal is to detect changes due to previously undetected injuries.

References:
[1]

Special cases

Certain clinical manifestations warrant immediate intervention or specific tests. Some common scenarios are:

- Penetrating wounds to the abdomen with hypovolemic shock (hypotension, pale, cold, barely detectable pulses)
    - Perform exploratory laparotomy for control of hemorrhage, then fluid resuscitation.
    - **Any penetrating wound below the nipple requires an exploratory laparotomy.**
    - **Do not delay transfer of patient to the operating room (or to a traumacenter) in favor of fluid resuscitation.**
    - See Approach to penetrating abdominal trauma.
- Gunshot wounds and signs of cardiac tamponade (hypotension, barely detectable pulses, distended neck veins)
    - Perform pericardial window, thoracotomy, and then exploratory laparotomy.
    - See Pericardial effusion and cardiac tamponade and Penetrating trauma.
- Gunshot wounds to the chest and abdomen with signs of tension pneumothorax (hypotension, distended neck veins, tracheal deviation, absent breath sounds over hemithorax)
    - Place chest tube; (or perform needle thoracostomy if

chest tube is not available).
    - See Approach to penetrating chest trauma.
- Allergic reaction (hypotension, tachycardia, respiratory distress, warm and swollen)
    - Administer epinephrine.
    - See Anaphylactic shock.
- High-energy trauma of the lower extremities (e.g., calcaneus fracture following a fall from a height)
    - Perform thoracolumbar spine x-rays to look for additional injuries
- High-energy trauma with widened mediastinum on x-ray
    - Perform CT Angiography for diagnosis of aortic injury and then perform surgical repair.
    - See Approach to blunt chest trauma.
- Blunt trauma with subcutaneous emphysema
    - Perform bronchoscopy for diagnosis of injury to the trachea and then perform surgical repair.
    - See Approach to blunt chest trauma .
- Blunt trauma with concern for cervical spine injury
    - Obtain cervical spine CT scan in patients with distracting injury (e.g., femoral fracture), altered mental status/intoxication,

focal neurologic deficit
, midline neck tenderness, or neck pain

- Signs of peritonitis
 (abdominal tenderness, rebound, guarding, rigid abdomen)
    - Perform exploratory
      laparotomy
       as it indicates perforated
      viscus
      .
    - See Approach to penetrating abdominal trauma.
    - See Approach to blunt abdominal trauma.
- Blood in the urinary meatus
    - Perform retrograde urethrogram (may be a bladder injury, but need to rule out urethral injury first).
    - See Traumatic injuries of the kidney and bladder.
- No blood in the urinary meatus, but
  hematuria
   through
  Foley catheter
    - Perform
      retrograde cystogram
       for diagnosis of bladder injury.
    - See Traumatic injuries of the kidney and bladder.
- Hematuria
   through
  Foley catheter
  , but normal
  retrograde cystogram
    - Perform
      CT scan
       for diagnosis of
      kidney injury
      .
    - See Traumatic injuries of the kidney and bladder.
- Large
  hematoma
   over the shaft of the
  penis
    - Perform emergent surgical repair of
      penile fracture
      .
- Human bite

  - Surgical exploration and debridement

  - See Bite wounds.
- Trauma during pregnancy

  - Examine mother in left lateral position to minimize inferior vena cava compression
  - Perform cesarean delivery iffetus > 24 weeks of gestation shows worsening signs of distress, or if mother is not responding to cardiopulmonary resuscitation

    Cardiopulmonary resuscitation

    Abbreviation: CPR

    An emergency procedure that maintains circulation in patients with cardiac arrest until cardiac function can be restored. Most commonly refers to Basic Life Support (BLS) or Advanced Cardiac Life Support (ACLS) algorithms. Consists of chest compression, rescue breathing, and defibrillation.

  Cardiopulmonary resuscitation

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Tactical combat casualty care (TCCC)

Trauma care guidelines used during combat and established in three phases. The aim is to reduce preventable deaths in military personnel during tactical missions. [10] [11]

Phase 1: care under fire (CUF)

- Implemented during active fire
- Continue tactical mission, return suppression fire, and take cover.
- Assist/direct casualties to control active bleeding with manual pressure or combat tourniquets.

Phase 2: tactical field care (TFC)

- Implemented when no longer under active fire
- Disarm casualties with altered mental status and/or recent

ketamine
 or
fentanyl
 therapy.

- First responders (soldiers or medical personnel) should treat casualties using the **MARCH** algorithm:
  - **M**assive hemorrhage: Reassess and control all sources of bleeding using a tourniquet and/or combat gauze.
  - **A**irway management: Assess airway patency; insert nasopharyngeal airway (NPA) or perform
    surgicalcricothyroidotomy
    , if necessary.
  - **R**espiration: Insert a vented chest seal in case of open chest wounds, decompress a suspected
    tension pneumothorax
    , and consider ventilation/oxygen therapy.
  - **C**irculation: Establish IV or
    IO access
     when
    fluid resuscitation
     and/or IV drug administration is required.
  - **H**ead injury/
    hypothermia
     prevention: Assess for
    concussion
    , remove wet clothes, and apply a ready-heat blanket.
- Additional measures should be considered at the Casualty Collection Point (CCP), using the **PAWS** algorithm:
  - **P**ain management: Administer
    analgesics
    .
  - **A**ntibiotics: 1 g IV
    ertapenem
     or 2 g IV
    cefotetan
     or 400 mg oral
    moxifloxacin
  - **W**ound management: Address open wounds, burns, and
    open fractures
    .

- **S**plinting: Stabilize pelvic fractures and shield eye injuries.

Phase 3: tactical evacuation care (TEC)

- Evacuate casualties via air or ground ambulance to the nearest medical facility.
- Continue interventions initiated during the TFC phase.
- Assess and document additional life-threatening injuries, pain control, fluid resuscitation, and appropriate therapy.

INTRODUCTION

The term "golden hour" is a well-known part of the lexicon of trauma surgeons and emergency medical service (EMS) providers who take care of injured patients on a daily basis. The underlying tenet is that an injured patient has 60 minutes from the time of injury to receive definitive care, after which morbidity and mortality increase significantly. Teleologically this seems to make great sense, as no one would argue that we should leave an injured patient bleeding on the streets for longer periods of time. Nevertheless, like many holy shrines in medicine, once exposed to the light of an evidencedbased review, it is found to lack conclusive evidence in the literature to support our biases. This article will briefly unpack the origins of the golden hour and look at evidence to refute or support it.

HISTORICAL BACKGROUND

The vernacular term "golden hour" is widely attributed to R. Adams Cowley, founder of Baltimore's famous Shock Trauma Institute. In a 1975 article, he stated, "the first hour after injury will largely determine a critically-injured person's chances for survival."1 However, no references or data were provided to support this statement. The foundation for this statement is a bit unclear, but it is widely believed that at the time he stated this, Cowley was trying to win support for a shock trauma hospital and a helicopter program that would fly any trauma victim in the state of Maryland to a trauma hospital in Baltimore within 60 minutes (the golden hour). A companion to the golden hour has arisen in pre-hospital lore called the "platinum 10 minutes." This is based on the concept that seriously injured patients should have no more than 10 minutes of scene-time stabilization by emergency medical personnel prior to transport to definitive care at a trauma center. This dogma likely arose from the military, as many battlefield fatalities occur within the first minutes post-injury.2 The idea that definitive trauma care must be initiated within 60 minutes has spawned a billion dollar industry of trauma systems, trauma centers, aeromedical rescue, and advanced pre-hospital life support. It has subjected the general public to significant potential risk from well-intentioned ambulance crews careening rapidly through busy streets, transporting injured patients in crowded driving conditions, or air ambulances flying in less than ideal weather. However, this concept is established on a less than rigorous scientific foundation. The fact of the matter is that there is a paucity of data to support the golden hour and even some data that refute it.

EVIDENCE IN FAVOR OF THE GOLDEN HOUR

Two of the most significant studies that found a significant correlation between reduced out-of hospital times and decreased mortality rates were from Quebec in the 1990's.3,4 The 1993 study by Sampalis et al3 found that total pre-hospital time over 60 minutes was associated with a significant increase in the odds of mortality. The 1999 study by the same group4 found that reduced pre-hospital time was associated with reduced odds of dying, when outcomes were controlled for the severity of injury and age of the patient. Additionally, reduced pre-hospital time has been found to be beneficial in specific patient populations, including severe head injuries,5,6 intra-abdominal bleeds,7 severe thoracic injuries,8-10 and rural trauma patients with long EMS transport times.11 Two EMS studies from the United States12,13 further supported the importance of shorter pre-hospital time periods: a 2002 study by Blackwell et al12 found that EMS response times of less than 5 minutes were associated with improved survival in a cohort of both life-threatening and non-life-threatening EMS calls, and a 2005 study by Pons et al13 found that EMS response times within 4 minutes resulted in a significant survival benefit for patients with intermediate and high risk of mortality. It is important to note that these studies12,13 included mixed populations, including patients with non-traumatic cardiac arrest.

NEGATIVE OR INCONCLUSIVE EVIDENCE FOR THE GOLDEN HOUR

The validity of the golden hour and the link between pre-hospital time and outcome are far from conclusive. With the exception of patients with non-traumatic cardiac arrest,14,15 no field-based population has consistently demonstrated a significant association between response interval and survival. One of the most comprehensive investigations of time-to-definitive care in trauma was a 2010 prospective cohort study by Newgardet al16 of

146 EMS agencies that transported patients to 51 trauma centers in North America. These investigators identified no relationship between EMS intervals and in-hospital mortality among injured patients with physiologic abnormalities. This finding persisted across several subgroups, including injury type, age, and mode of transport.16 A 2012 German study by Kleberet al17 found similar results, identifying no significant survival advantage for trauma patients with shorter pre-hospital rescue times. This finding is supported by studies conducted in Canada,18 the United States,19-22 and Italy.23 Despite the conflicting evidence regarding the golden hour, rapid EMS transport to medical facilities remains the standard of trauma care. Yet, in the aggregate, there is significant evidence indicating that many trauma patients do not need to be rushed to the hospital.16-23 Some research even indicates that a slower, smoother transport to the hospital would be beneficial to both patients and pre-hospital providers. A 2010 study by Chung et al24 found that increased ambulance speed negatively affects the quality of chest compression during transport. EMS workers have a documented fatality rate of 12.7 per 100,000 workers, more than twice the national average of 5.0 per 100,000.25 By some estimates, the risk of transportation-related injury to EMS workers and their patients may be five times the national average risk of transit injury.26 These deaths and injuries are largely attributed to helicopter and ambulance crashes that result from the emphasis on shorter pre-hospital time frames.27,28

PERSPECTIVES

There are limitations to the evaluations of the significance of the golden hour. For example, there are multiple time periods that may be evaluated, including time between the event and notification of 911 (discovery time), 911 notification to hospital arrival (EMS transport time), and hospital arrival to treatment. As a result, there are many different contexts in which the golden hour can be evaluated. Also, determining precise time periods can be quite difficult. For instance, the time of injury and death may be inconsistently recorded. The exact time of injury and death may be unknown if unobserved. Further, declaration of death may be delayed until after resuscitative efforts have been judged futile. This inexactness results in difficulty evaluating time to definitive care and time to death.29 Certainly there are significant potential negative effects of discrediting the golden hour. Misinterpretation of literature questioning the significance of time to definitive care could have unfortunate consequences for patient care if health administrators begin to use recent research studies as proof that they no longer need to invest in timely care of trauma patients. They may cut transport services and reduce staff and funding of trauma centers. This would be a great misfortune for trauma patients, as a 2006 study by MacKenzieet al30 demonstrated a 25% reduction in mortality with designation as a trauma center. The implications of the literature refuting the golden hour must be carefully examined before any hasty changes are made to current trauma and EMS care models.

CONCLUSIONS

This article is not an attempt to totally disregard the importance of the golden hour dictum. True, there is an aspect of trauma care that is very time dependent, but it is wrong to apply an arbitrary time limit such as one hour to a patient in need of definitive care. Every patient coming through the ED doors to the trauma resuscitation area is unique. For a patient who has a gunshot wound to the heart with rupture of the left ventricle, the difference between life and death may be a golden 5 minutes, not a golden hour. Conversely, for a patient who is in a car accident and has an isolated tibia fracture, it may be a golden day or two. In the year 2014, it is important to look at the evidence-based medicine that either supports or refutes our widely held beliefs. In this way, we can begin to more intelligently design a trauma care system that begins to address the needs of each patient.

STABILIZATION AND OPTIMIZATION

2.0 Airway and Chest trauma Management

2.1 Airway Assessment 2.1.1 A clinical examination of the thorax and respiratory function must be carried out. 2.1.2 The examination should include as a minimum the measurement of the respiratory rate and auscultation of the lungs. The examination should be repeated. 2.1.3 The following can be helpful: inspection (bilaterally unequal in respiratory excursion, unilateral bulging, paradoxical respiration), palpation (pain, crepitations, subcutaneous emphysema, instability) and percussion (hyperresonant percussion) of the thorax together with pulse oxymetry and, in ventilated patients, monitoring ventilation pressure(if available). 2.2 Securing Airway 2.2.1 Manual in-line stabilization should be carried out for endotracheal intubation with the cervical spine immobilization device temporarily removed. 2.2.2 A difficult airway must be anticipated when endotracheally intubating a trauma patient. 2.2.3 The multiply injured patient must be preoxygenated before anesthesia. 2.2.4 Use drug-assisted rapid sequence induction (RSI) of anaesthesia and intubation as the definitive method of securing the airway in patients with major trauma who cannot maintain their airway and/or ventilation. 2.2.5 If RSI fails, use basic airway manoeuvres and adjuncts and/or a supraglottic device until a surgical airway or assisted tracheal placement is performed. Standard Treatment Guidelines-Major Trauma 9 2.2.6 If difficult anesthetization and/or endotracheal intubation are expected, an anesthesiologist must carry out or supervise this procedure in-hospital provided this does not cause delay in an emergency life-saving measure. Suitable measures must be in place to ensure that an anesthesiologist is normally on site in time 2.2.7 After more than 3 intubation attempts, alternative methods must be considered for ventilation and securing an airway. 2.2.8 Alternative methods for securing an airway must be provided when anesthetizing and endotracheally intubating a multiply injured patient. *Alternatives like emergency cricothyroidotomy or surgical airway 2.2.9 Etomidate should be avoided as an induction agent due to the associated side effects on adrenal function . *Ketamine can be used as a safe alternative as an induction agent. Dose- 1-2 mg/kg, time to effect of 45-60 seconds. 2.2.10 ECG, blood pressure measurement, pulse oxymetry and capnography(if available) must be used to monitor the patient for anesthesia induction, endotracheal intubation and emergency anesthesia. 2.2.11 Normoventilation must be carried out in endotracheally intubated and anesthetized trauma patients. 2.2.12 Ventilation must be monitored and controlled by frequent arterial blood gas analyses(if available) in the hospital. If ABG analysis not available, then keep a check clinically by observing the chest rise & four point auscultation of the chest. 2.2.13 In mandible and maxillofacial injuries, primary securing of the airways and hemostasis in the oral and maxillofacial region must be carried out. 2.3 Chest Trauma Diagnosis and Management 2.3.1 A suspected diagnosis of pneumothorax and/or hemothorax must be made if breath sounds are weaker or absent on one side (after checking correct placement of the tube). Absence of such auscultation findings largely rules out a larger pneumothorax, especially if the patient is normopneic and has no chest pain. 2.3.2 A suspected diagnosis of tension pneumothorax should be made if auscultation of the lung reveals no breath sounds unilaterally (after checking correct placement of the tube) and, in addition, typical symptoms are present, particularly severe respiratory disorder or upper inflow congestion combined with arterial hypotension. 2.3.3 Clinically suspected tension pneumothorax must be decompressed* immediately. *Chest decompression mainly refers to tube thoracostomy/ Chest drain placement. 2.3.4 Use open thoracostomy instead of needle decompression if the expertise is available, followed by a chest drain via the thoracostomy in patients who are breathing spontaneously. *Open method of chest drain insertion to be preferred over trocar method. Needle decompression should not be attempted unless absolutely indicated. 2.3.5 Observe patients after chest decompression for signs of recurrence of the tension pneumothorax. 2.3.6 In patients with an open pneumothorax: cover the open pneumothorax with a simple occlusive dressing and observe for the development of a tension pneumothorax. 2.3.7 Pneumothorax diagnosed on the basis of an auscultation finding in a patient on positive pressure ventilation should be decompressed. 2.3.8

Pneumothorax diagnosed on the basis of an auscultation finding in patients not on ventilation should usually be managed by close clinical observation. 2.3.9 Pneumothorax should be treated with a chest drain provided the indication exists. 2.3.10 If there are perforating chest injuries, embedded foreign bodies should only be removed during surgery under controlled conditions after opening up the chest. 2.3.11 A penetrating chest injury, which is the cause of hemodynamic instability in the patient, must undergo an immediate exploratory thoracotomy. 2.3.12 A thoracotomy can be performed if there is an initial blood loss of > 1,500 ml from the chest drain or if there is persistent blood loss of > 250 ml/h over more than 4 hours. 2.4 Imaging in Chest Trauma 2.4.1 Imaging for chest trauma in patients with suspected chest trauma should be performed urgently, and the images should be interpreted immediately by a healthcare professional with training and skills in this area. 2.4.2 Consider immediate chest X-ray and/or eFAST (extended focused assessment with sonography for trauma) as part of the primary survey to assess chest trauma with severe respiratory compromise. 2.4.3 Consider immediate CT for those with suspected chest trauma without severe respiratory compromise who are responding to resuscitation or whose haemodynamic status is normal. 3.0 Haemorrhage and Shock 3.1 Dressings and tourniquets in hospital settings 3.1.1 Use simple dressings* with direct pressure to control external haemorrhage. *sterile gauze pads 3.1.2 In patients with major limb trauma use a tourniquet* if direct pressure has failed to control life-threatening haemorrhage. *a bandage,a strip of cloth,a band of rubber,etc.,that checks bleeding or blood flow by compressing the blood vessels 3.2 Haemostatic agents in hospital settings 3.2.1 Use intravenous tranexamic acid as soon as possible in patients with major trauma and active or suspected active bleeding. Dosage as German guidelines Tranexamic acid initially 1 g i.v. as saturation over 10 minutes + 1 g over 8 hours (CRASH 2 Trials) * Or 2 g (15–30 mg/kg) 3.2.2. Do not use intravenous tranexamic acid more than 3 hours after injury in patients with major trauma. Standard Treatment Guidelines-Major Trauma 11 3.3 Anticoagulant reversal in hospital settings 3.3.1 Rapidly reverse anticoagulation in patients who have major trauma with haemorrhage. 3.3.2 FFP (10-15ml/kg body weight)is recommended when there is bleeding associated with clotting factors deficiency and if no alternative processed products or specific factor concentrates are available. If immediate reversal of warfarin effect is required. Intravenous vitamin K 5mg should be concurrently given for sustained reversal of warfarin effect *Management of bleeding following major trauma: an updated European guideline Rolf Rossaint et al. 3.3.3 Consult a physician immediately for advice on adults (18 or over) who have active bleeding and need reversal of any anticoagulant agent other than a vitamin K antagonist. 3.3.4 Do not reverse anticoagulation in patients who do not have active or suspected bleeding. 3.4 Trauma induced coagulopathy 3.4.1 Trauma-induced coagulopathy is an autonomous clinical picture with clear influences on survival. For this reason, coagulation diagnostic tests* and therapy must be started immediately in the emergency room. *Coagulation diagnostic tests - Platelets, PT/INR, APTT and Fibrinogen (if available) 3.5 Activating major haemorrhage protocols in hospital settings 3.5.1 Use physiological criteria that include the patient's haemodynamic status and their response to immediate volume resuscitation to activate the major haemorrhage protocol. 3.5.2 Do not rely on a haemorrhagic risk tool* applied at a single time point to determine the need for major haemorrhage protocol activation. *For example: ABC score, TASH score, PWH score, McLaughlin score, Emergency transfusion score, Shock Index etc These measure variables at a single point in time. 3.6 Circulatory access in hospital settings 3.6.1 For circulatory access in patients with major trauma in hospital settings: use peripheral intravenous access (14 or 16 gauge intravenous cannula) or if peripheral intravenous access fails, a venous cutdown should be done. 3.7 Volume resuscitation in hospital settings 3.7.1 For patients with active bleeding use a restrictive*/balanced approach to volume resuscitation until definitive early control of bleeding has been achieved, *Restrictive resuscitation - in order to keep the circulation at a low stable level (Systolic BP: 90 mmHg or palpable central pulse) and not exacerbate the bleeding. (from the german guidelines) 3.7.2 In hospital settings, titrate volume resuscitation to maintain a palpable central pulse (carotid or femoral). 3.7.3 For patients who have haemorrhagic shock and a traumatic brain injury: if haemorrhagic shock is the dominant condition, continue restrictive volume resuscitation or if traumatic brain injury is the dominant condition, use a less restrictive volume resuscitation approach to maintain cerebral perfusion. Standard Treatment Guidelines-Major Trauma 12 3.7.4 Damage Control resuscitation: ● In patients who are actively bleeding, the goal can be set at mean arterial pressure ~ 65 mmHg and systolic arterial pressure ~ 90 mmHg until surgical hemostasis. ● Suitable measures should be taken and treatment given to avoid hypothermia. ● Acidemia should be avoided and treated by suitable treatment. 3.8 Fluid replacement in hospital settings 3.8.1 In hospital settings, only use crystalloids* to replace fluid volume in patients with active bleeding if blood components are not available. * preferably Normal saline,Ringers lactate. Glucose containing fluid should be avoided in (a head injury) patients, during initial resuscitation. 3.8.2 Human albumin must not be used in hospital volume replacement. 3.8.3

Colloidal solutions can be used in hypotensive trauma patients, if available and preference should be given to HES 130/0.4. 3.9 Haemorrhage protocols in hospital settings 3.9.1 Hospital should have specific major haemorrhage protocols for adults. 3.9.2. For patients with active bleeding, start with a fixed-ratio protocol (1:1:1 FFP: platelets: RBC) for blood components and change to a protocol guided by laboratory coagulation results at the earliest opportunity. In patients with Grade 3 and 4 hemorrhagic shock with imminent threat to life and if components are not available then whole blood can be given to stabilize the patient before transferring to a higher centre[MK5] . 3.9.3 In an actively bleeding patient, the indication for transfusion can be made at hemoglobin levels below 10 g/dL, and the hematocrit value maintained at 30%. 3.9.4 In critically ill trauma patients, transfusion strategy to be employed ● Hb concentration 9 g/dL, RBC transfusion is generally unnecessary. 3.9.5 Red blood cell (RBC) transfusion should not be dictated by a haemoglobin (Hb) concentration alone, but should also be based on assessment of the patient's clinical status 3.9.6 Replacement of fibrinogen should be carried out, if test provisions are available, at levels < 1.5 g/l (150 mg/dl). 3.10 Haemorrhage imaging in hospital settings 3.10.1 Imaging for haemorrhage in patients with suspected haemorrhage should be performed urgently, using FAST, and a CT if required, and the images should be interpreted immediately by a healthcare professional with training and skills in this area. Standard Treatment Guidelines-Major Trauma 13 3.10.2 Limit diagnostic imaging (such as chest and pelvis X-rays or FAST [focused assessment with sonography for trauma]) to the minimum needed to direct intervention in patients with suspected haemorrhage and haemodynamic instability who are not responding to volume resuscitation. 3.10.3 Be aware that a negative FAST does not exclude intraperitoneal or retroperitoneal haemorrhage. *To repeat a FAST examination if clinical index of suspicion for intraperitonealhemorrhage. 3.10.4 Consider immediate CT for patients with suspected haemorrhage only if they are responding to resuscitation or if their haemodynamic status is normal. 3.11 Damage control surgery 3.11.1 Use damage control surgery in patients with haemodynamic instability who are not responding to volume resuscitation. 3.12 Resuscitation (Criteria for Cardiac arrest after trauma) 3.12.1 In the case of definitive cardiac arrest or uncertainties in detecting a pulse or other clinical signs that make cardiac arrest likely, resuscitation must be started immediately 3.12.2 During resuscitation, trauma-specific reversible causes of cardiac arrest ., airway obstruction, esophageal intubation, hypovolemia, tension pneumothorax or pericardial tamponade) should be diagnosed and treated. 3.12.3 If resuscitation is unsuccessful after eliminating possible causes of cardiac arrest, cardiopulmonary resuscitation must be stopped. 3.13 Role of Emergency Thoracotomy 3.13.1 If expertise is available, emergency thoracotomy should be performed in the case of penetrating injuries, particularly if the onset of cardiac arrest is recent and vital signs are initially present. 4.0 Head Injury initial management 4.1.1State of consciousness with pupil function and Glasgow Coma Scale (bilateral motor function) must be recorded and documented at repeated intervals. 4.1.2 The goals are normoxia*, normocapnia**, and normotension***. A fall in arterial oxygen saturation below 90% must be avoided. *Normoxia- sPO2>90% **Normocapnia - paCO2 = 35 -40 mmHg{4.7kPa} ***Normotension - SBP ≥90 mmHg 4.1.3 Intubation with adequate ventilation (with capnometry and blood gas analysis if available) must be carried out in unconscious patients (reference value GCS ≤ 8). Standard

Treatment Guidelines-Major Trauma 14 4.1.4 A Cranial Computed Tomography scan must be performed in the case of polytrauma after stabilization with suspected traumatic brain injury. 4.1.5 A (monitoring) CT scan must be performed in the case of neurologic deterioration. 4.1.6 Glucocorticoids must not be administered in the treatment of TBI. 4.1.7 If severely elevated intracranial pressure is suspected, particularly with signs of transtentorial herniation (pupil widening, decerebrate rigidity, extensor reaction to painful stimulus, progressive clouded consciousness), the following treatments can be given: ● Hyperventilation where ABG analysis is available* ● Mannitol** * 20 breaths per minute to maintain paCO2 at 30-35 mm of Hg **20% solution at 0.5-2 gm/kg over 30 to 60 minutes 5.0 Spinal Injury Management 5.1 Assessment for spinal injury 5.1.1 On arrival at the hospital, use a prioritising sequence to assess people with suspected trauma, for example ABCDE: ● Airway with in-line spinal immobilisation ● Breathing ● Circulation ● Disability (neurological) ● Exposure and environment. 5.1.2 At all stages of the assessment: ● protect the person's cervical spine with manual in-line spinal immobilisation, particularly during any airway intervention and ● avoid moving the remainder of the spine. 5.1.3 History and thorough clinical examination for spinal injury including the functions associated with it must be carried out. 5.1.4. The spine is suspected to be stable, unless any of the following 5 criteria are present, · impaired consciousness ● neurologic deficit ● spinal pain or myogelosis ● intoxication ● trauma in the extremities *myogelosis (area of hard or stiff muscle) 5.1.5 The presence of a spinal injury must be assumed in unconscious patients until evidence to the contrary is found. 5.1.6 Carry out full in-line spinal immobilisation if any of the factors in recommendation 4.1.4 are present or if this assessment cannot be done. Standard

Treatment Guidelines-Major Trauma 15 5.2Assessment of Cervical Spine 5.2.1 Assess whether the person is at high, low or no risk for cervical spine injury using the Canadian C-spine rule as follows: ➔ the person is at high risk if they have at least one of the following high-risk factors: ● age 65 years or older ● dangerous mechanism of injury (fall from a height of greater than 1 metre or 5 steps, axial load to the head – for example diving, high-speed motor vehicle collision, rollover motor accident, ejection from a motor vehicle, accident involving motorised recreational vehicles, bicycle collision, horse riding accidents) ● paraesthesia in the upper or lower limbs ➔ the person is at low risk if they have at least one of the following low-risk factors: ● involved in a minor rear-end motor vehicle collision ● comfortable in a sitting position ● ambulatory at any time since the injury ● no midline cervical spine tenderness ● delayed onset of neck pain ➔ the person remains at low risk if they are: ● unable to actively rotate their neck 45 degrees to the left and right (the range of the neck can only be assessed safely if the person is at low risk and there are no high-risk factors).t ➔ the person has no risk if they: ● have one of the above low-risk factors and, ● are able to actively rotate their neck 45 degrees to the left and right. 5.3 Assessment of Thoracic or Lumbosacral Spine 5.3.1 Assess the person with suspected thoracic or lumbosacral spine injury using these factors: ● age 65 years or older and reported pain in the thoracic or lumbosacral spine ● dangerous mechanism of injury (fall from a height of greater than 3 metres, axial load to the head or base of the spine – for example falls landing on feet or buttocks, high-speed motor vehicle collision, rollover motor accident, lap belt restraint only, ejection from a motor vehicle, accident involving motorised recreational vehicles, bicycle collision, horse riding accidents) ● pre-existing spinal pathology, or known or at risk of osteoporosis – for example steroid use ● suspected spinal fracture in another region of the spine ● abnormal neurological symptoms (paraesthesia or weakness or numbness) ● on examination: ➢ abnormal neurological signs (motor or sensory deficit) ➢ new deformity or bony midline tenderness (on palpation) ➢ bony midline tenderness (on percussion) Standard Treatment Guidelines-Major Trauma 16 ➢ midline or spinal pain (on coughing) ● on mobilisation (sit, stand, step, assess walking): pain or abnormal neurological symptoms (stop if this occurs). 5.4 When to carry out in-line spinal immobilisation 5.4.1 Carry out or maintain full in-line spinal immobilisation if: ● a high-risk factor for cervical spine injury is identified and indicated by the Canadian Cspine rule ● a low-risk factor for cervical spine injury is identified and indicated by the Canadian Cspine rule and the person is unable to actively rotate their neck 45 degrees left and right ● indicated by one or more of the factors listed in recommendation 5.3.1 5.4.2 Do not carry out or maintain full in-line spinal immobilisation in people if: ● they have low-risk factors for cervical spine injury and, are pain free and are able to actively rotate their neck 45 degrees left and right ● they do not have any of the factors listed in recommendation 5.3.1 5.5 How to carry out full in-line spinal immobilisation 5.5.1 The spinal immobilisation devices need to be adjusted In uncooperative, agitated or distressed people, think about letting them find a position where they are comfortable with manual in-line spinal immobilisation. 5.5.2 When carrying out full in-line spinal immobilisation in adults, manually stabilise the head with the spine in-line using the following stepwise approach: ● Fit an appropriately sized semi-rigid collar unless contraindicated by: ➔ a compromised airway ➔ known spinal deformities, such as ankylosing spondylitis (in these cases keep the spine in the person's current position). ● Reassess the airway after applying the collar. ● Place and secure the person on a stretcher. 5.6 When to carry out or maintain full in-line spinal immobilisation and request imaging 5.6.1 Carry out or maintain full in-line spinal immobilisation and request imaging if: ● a high-risk factor for cervical spine injury is identified and indicated by the Canadian Cspine rule or ● a low-risk factor for cervical spine injury is identified and indicated by the Canadian Cspine rule and the person is unable to actively rotate their neck 45 degrees left and right or ● indicated by one or more of the factors listed in recommendation 4.3.1 5.6.2 Do not carry out or maintain full in-line spinal immobilisation or request imaging for people if: Standard Treatment Guidelines-Major Trauma 17 ● they have low-risk factors for cervical spine injury as identified and indicated by the Canadian C-spine rule, are pain free and are able to actively rotate their neck 45 degrees left and right ● they do not have any of the factors listed in recommendation 4.3.1 5.7 Diagnostic imaging 5.7.1 Imaging for spinal injury should be performed urgently, and the images should be interpreted immediately by a healthcare professional with training and skills in this area after stabilisation. 5.7.2 Perform CT in adults if; ● imaging for cervical spine injury is indicated by the Canadian C-spine rule (see recommendation 4.6.1) or ● there is a strong suspicion of thoracic or lumbosacral spine injury associated with abnormal neurological signs or symptoms. C spine xray should be considered if CT is not available with caution of high false negative rate. 5.7.3 If, after CT, there is a neurological abnormality which could be attributable to spinal cord injury, advice MRI. 5.8 Lumbosacral Spine Imaging 5.8.1 Perform an X-ray as the first-line investigation for people with suspected spinal column injury without abnormal neurological signs or symptoms in the thoracic or lumbosacral regions (T1–L3). 5.8.2 Perform CT if the X-ray is abnormal or there are clinical signs or symptoms of a spinal column injury. 5.8.3 If a new spinal column fracture is confirmed, image the rest of the spinal column. 5.8.4 After circulatory stabilization and before transfer from the emergency room, a spinal injury should be cleared by clinical examination or imaging . (if available). 5.9 Medications 5.9.1 Do not use the following medications, aimed at providing neuroprotection and prevention of secondary deterioration, in the acute stage after acute traumatic spinal cord injury: ● Methylprednisolone ● Nimodipine ● Naloxone. 5.9.2 Do not use medications in the acute stage after traumatic spinal cord injury to prevent neuropathic pain from developing in the chronic stage. 6.0 Pelvic Fracture Management 6.1 Using a pelvic binder 6.1.1. An acute life-threatening pelvic injury must be excluded when the patient is admitted to the hospital. Standard Treatment Guidelines-Major Trauma 18 6.1.2 The stability of the patient's pelvis must be clinically examined. 6.1.3 If active bleeding is suspected from a pelvic fracture following blunt high-energy trauma, apply a pelvic binder. 6.2 Pelvic imaging 6.2.1 During the diagnostic study a pelvic survey radiograph should be taken and/or computed tomography (CT) be performed once patient is stabilized*. *unstable patients do portable X-Ray if available 6.2.2 Use CT (if available, otherwise X-ray) for first-line imaging with suspected high-energy pelvic fractures once patient is stabilized 6.2.3 Unstable patients with suspected active bleeding from pelvic fracture, use: ● pelvic packing to stabilize the patient. 6.3 Removing a pelvic binder 6.3.1 For people with suspected pelvic fractures and pelvic binders, remove the binder as soon as possible if: ● there is no pelvic fracture, or ● a pelvic fracture is identified as mechanically stable, or ● the binder is not controlling the mechanical stability of the fracture, or ● there is no further bleeding or coagulation is normal. Remove all pelvic binders within 24 hours of application. 6.4 Log rolling 6.4.1 Do not log roll people with suspected pelvic fractures before pelvic imaging unless: ● an occult penetrating injury is suspected in a person with haemodynamic instability ● log rolling is needed to clear the airway (for example, suction is ineffective in a person who is vomiting). ● When log rolling, pay particular attention to haemodynamic stability. 7.0 Management of open fractures and complications 7.1 Open fractures 7.1.1 Do not irrigate open fractures of the long bones, hindfoot or midfoot in the emergency department before debridement. 7.1.2 Consider a saline-soaked dressing covered with an occlusive layer (if not already applied) for open fractures in the emergency department before debridement. 7.1.3 In the emergency department, administer prophylactic intravenous antibiotics immediately to people with open fractures if not already given. 7.1.4 Do not base the decision whether to perform limb salvage or amputation on an injury severity tool score. 7.1.5 Perform emergency amputation when: ● A limb is the source of uncontrollable life-threatening bleeding, or ● A limb is salvageable but attempted preservation would pose an unacceptable risk to the person's life, or ● A limb is deemed unsalvageable after orthoplastic assessment 7.1.6 Perform debridement: ● Immediately for highly contaminated open fractures ● Within 24 hours of injury for all other open fractures management 7.2 Vascular injury 7.2.1 Use hard signs (lack of palpable pulse, continued blood loss, or expanding haematoma) to diagnose vascular injury. 7.2.2 Do not rely on capillary return or Doppler signal to exclude vascular injury. 7.2.3 Perform immediate surgical exploration if hard signs of vascular injury persist after any necessary restoration of limb alignment and joint reduction. Do not delay revascularisation for angiography in people with complex fractures 7.3 Compartment syndrome 7.3.1 In people with fractures of the tibia, maintain awareness of compartment syndrome for 48 hours after injury or fixation by regularly assessing and recording clinical symptoms and signs in hospital 8.0 Pain management in Major trauma 8.1.1 Assess pain regularly in patients with major trauma using a pain assessment scale suitable for patients cognitive function. 8.1.2 For patients with major trauma, use intravenous morphine/opiods as the first-line analgesic and adjust the dose as needed to achieve adequate pain relief. Dose of Morphine – 2.5-5 mg/kg q 4h Pentazocine Dosing: Adult IV: 30 mg every 3-4 hours. Butorphanol:IV: Initial: 1 mg, may repeat every 3-4 hours as needed. Buprenorhine:Slow IV: Initial: 0.3 mg every 6 to 8 hours as needed; 8.1.3 Consider ketamine in analgesic doses as a second-line agent. *Dose of Ketamine 1-4.5 mg/kg (medscape) 8.2 Efficacy of Analgesic Modalities in blunt thoracic trauma 8.2.1 Epidural analgesia is the preferred mode of analgesia delivery in severe thoracic trauma. 9.0 Providing support and Information to patients & relatives Providing information about patients to the next level hospital/casualty 9.1 Providing support 9.1.1 When communicating with patients, family members and carers ● manage expectations and avoid misinformation ● answer questions and provide information honestly, within the limits of your knowledge Standard Treatment Guidelines-Major Trauma 20 ● do not speculate and avoid being overly optimistic or pessimistic when discussing information on further investigations, diagnosis or prognosis ● ask if there are any other questions. 9.1.2 The trauma team structure should include a clear point of contact for providing information to patients, their family members and carers. 9.2 Providing information 9.2.1 Explain to patients, family members and carers what is happening and why it is happening. Provide: ● information on known injuries ● details of immediate investigations and treatment, and if possible include time schedules. 9.2.2 Offer people with fractures the opportunity to see images of their injury, taken before and after treatment. 9.2.3 Provide people with fractures on the following when the management plan is agreed or changed: ● expected outcomes of treatment, including time to returning to usual activities and the likelihood of permanent effects on quality of life (such as pain, loss of function and psychological effects) ● amputation, if this is a possibility ● activities they can do to help themselves ● home care options, if needed ● rehabilitation, including whom to contact and how (this should include information on the importance of active patient participation for achieving goals and the expectations of rehabilitation) ● mobilisation and weight-bearing, including upper limb load bearing for arm fractures. 9.2.4 Document all key communications with patients, family members and carers about the management plan. 9.2.5 Ensure that all health and social care practitioners have access to information previously given to people with fractures to enable consistent information to be provided. 9.3 Providing information about transfer from an emergency department 9.3.1 For patients who are being transferred from an emergency department to another centre, provide verbal and written information that includes: ● the reason for the transfer ● the location of the receiving centre and the patient's destination within the receiving centre ● the name and contact details of the person responsible for the patient's care at the receiving centre (if possible) ● the name and contact details of the person who was responsible for the patient's care at the initial hospital. 9.4 Recording information in before transferring to definitive care settings Standard Treatment Guidelines-Major Trauma 21 9.4.1 Record the following in people with major trauma in hospital settings: ● ABCDE (airway with in-line spinal immobilisation, breathing, circulation, disability [neurological], exposure and environment) ● History and Examination. 9.4.2 If possible, record information on whether the assessments show that the person's condition is improving or deteriorating. 9.4.3 Record pre-alert information using a structured system and include all of the following: ● the patient's age and sex ● time of incident ● mechanism of injury ● injuries suspected ● signs, including vital signs and Glasgow Coma Scale ● treatment so far ● estimated time of arrival at emergency department ● special requirements ● the ambulance call sign, name of the person taking the call and time of call ● 9.5 Training and skills 9.5.1 Ensure that each healthcare professional within the trauma service has the training and skills to deliver, safely and effectively, the interventions they are required to give as per this guideline. Training in the form of ATLS, NTMC, EMTC etc 9.6 Receiving information in hospital settings 9.6.1 Casualty Medical Officer/Trauma team leader in the emergency department should receive the pre-alert information, and determine the level of trauma team response according to agreed and written local guidelines. 9.6.2 The trauma team leader should be easily identifiable to receive the handover and the trauma team ready to receive the information. 9.6.3 The pre- hospital documentation, including the recorded pre-alert information, should be quickly available to the trauma team and placed in the patient's hospital notes. 9.7 Sharing information in hospital settings 9.7.1 Follow a structured process when handing over care within the emergency department (including shift changes) and to other departments. Ensure that the handover is documented. 9.7.2 Ensure that all patient documentation, including images and reports, goes with the patient when they are transferred to other departments or centres. 9.7.3 Produce a written summary, which gives the diagnosis, management plan and expected outcome and: ● is aimed at and sent to the patient's referring physician/surgeon/primary or secondary care hospital within 24 hours of admission

The introduction of trauma teams has improved patient outcome independently. The aim of establishing a trauma team is to ensure the early mobilization and involvement of more experienced medical staff and thereby to improve patient outcome. The team approach allows for distribution of the several tasks in assessment and resuscitation of the patient in a ‘horizontal approach’, which may lead to a reduction in time from injury to critical interventions and thus have a direct bearing on the patient’s ultimate outcome. A trauma team leader or supervisor, who coordinates the resuscitation and ensures adherence to guidelines, should lead the trauma team. There is a major national and international variety in trauma team composition, however crucial are a surgeon, an Emergency Medicine physician or both and anaesthetist. Advanced Trauma Life Support training, simulation-based training, and video review have all improved patient outcome and trauma team performance. Developments in the radiology, such as the use of computed tomography scanning in the emergency room and the endovascular treatment of bleeding foci, have changed treatment algorithms in selected patients. These developments and new insights in shock management may have a future impact on patient management and trauma team composition.

objectives

- The horizontal distribution of tasks between team members reduces the time from injury to critical interventions.
- Organizing the staff caring for seriously injured patients into trauma teams improves outcomes.
- Simulation training of teams improves performance but must be repeated on a regular basis if the effect is to be sustained.
- Videoing and review of real and simulated trauma resuscitations can be used for training and audit.

Trauma is the leading cause of death in the age group up to 44 yr in the Western world,
despite improvements in trauma care over the last four decades.

The current model of civilian trauma systems was first in the USA with the adoption in the American Congress of the Emergency Medical Systems

Act, Public Law 93–154, on November 1, 1973. The intention was to set up an area-wide emergency medical system. [4] The rationale for this was that failure to provide sufficient specialized care in an early phase of major trauma had been demonstrated to be a major shortcoming in the management of seriously injured patients. [5] One of the improvements in trauma care that resulted from this law was the introduction of multidisciplinary trauma teams. A trauma team aims to rapidly resuscitate and stabilize the patient, and to reduce the time to diagnosis and treatment with the overall objective of improving survival rates. Cowley [6] was among the first to conclude that having different specialities in a trauma centre is a necessity to reduce mortality. In the next decade, more studies came to this conclusion.

Trauma team composition

A team approach allows for distribution of the several tasks in assessment and resuscitation of the patient among a number of people. This ‘horizontal approach’ can lead to a reduction in time from injury to critical interventions. Driscoll and Vincent [11] showed that the time to complete the primary survey had a direct bearing on the patient’s ultimate outcome.

Outcomes from the initial assessment and resuscitation of trauma patients are improved by an organized trauma team.

[12]

[13]

There is variation, both nationally and internationally, in trauma team composition. However, the different approaches have much in common and an example of a trauma team composition and tasks are summarized in Figure 1 and Table 1.

Table 1Tasks of the trauma team members in the University Medical Centre Utrecht

Anaesthetist
• Airway management • Intubation • Ventilation •

Performs procedures

Surgeon/team leader

- Initial assessment and survey
- Coordinates team activities
- Performs procedures

Primary nurse

- Calls alert
- Records vital information
- Assists with procedures of surgeon

Neurologist
• Neurological evaluation
Radiology technician
• Films as needed Chest Pelvis
Radiologist
• Performs FAST if needed • Reads films •

Prepares CT
Secondary nurse
• Assists with airway management • Places monitoring devices • Sets up ventilator
Emergency physician/physician assistant
• Records vital signs • Venous access/draws blood • Inserts urinary catheter

• Assists performed procedures
Circulating nurse
• Brings blood • Carries blood samples • Prepares transport

- Open table in a new tab

The treatment of seriously injured patients requires the rapid assessment of injuries and institution of life-preserving therapy. The trauma team leader is often a surgeon who coordinates the resuscitation and ensures adherence to Advanced Trauma Life Support (ATLS) guidelines. Depending on the local situation, the trauma team can be led by an emergency physician as well. In the basic set up, an anaesthetist, one or two emergency department (ED) nurses, and a radiology technician join the team leader. The assessment and treatment of a protected unobstructed airway, which takes priority over management of all other conditions in the primary survey, is usually carried out by the anaesthetist, but can also be done by an intensivist, surgeon, or Emergency Medicine physician, depending on local agreements. The team leader interprets the results of the assessment of breathing and circulation and procedural treatment of injuries is provided if necessary. The nurses assist the medical staff and perform various tasks such as obtaining vital signs, performing or assisting with activities like i.v. access, drawing of blood, and undertaking urinary and gastric catheter placement. In many institutions, a nurse may also act as scribe, keeping a contemporaneous record of the management of the patient.

In some units, a neurologist or a neurosurgeon can be present for the determination of the Glasgow coma score, pupillary light response, and focal neurological deficit. In other hospitals, the surgeon or emergency physician will perform the primary neurological examination and consult a specialist when necessary.

A radiology technician should be present to make conventional X-rays of the thorax and pelvis as adjuncts to the primary survey. If a focused assessment sonography in trauma (FAST) is indicated, a radiologist should be present as well. The radiologist can either be a member of the trauma team or can be on site and be paged by the trauma team if necessary.

Usually, additional personnel such as junior surgical residents, emergency physician residents, or respiratory technicians are members of the trauma team as well. It is important not to have excessive numbers of people in the team, since it is more difficult to ensure the overview by the team leader and adherence to ATLS protocol by all team members.
[11]

Many hospitals have developed a tiered trauma team response. Depending on the reported trauma mechanism, expected injuries, and physiological parameters, the appropriate trauma team is requested.

Information from prehospital medical personnel is important for guiding the appropriate response and for assembly and preparation of the appropriate trauma team.

[17]

Depending on a triage system, patients are directed to the adequate level hospital,

[18]

[19]

and trauma team activation is requested. The coordinating ED nurse will then activate the appropriate team, according to the activation criteria (Table 2). Evaluation of the current practice has shown that a considerable rate of overtriage is necessary in order to prevent undertriage, and thus a delay in mobilizing the trauma team.

[20]

Table 2Trauma team activation criteria in the University Medical Centre Utrecht. GCS, Glasgow coma score; BSA, body surface area

Mechanism	Motor vehicle accident	• Speed over 80 km h^{-1} •

		Ejection/roll over/trapped • Unrestrained/fatality
	Motor bicycle	• Any with speed >30 km h^{-1}
	Pedestrian/cyclist	• Struck by car or motorcycle/any speed
	Fall	• Adult >3 m and/or 5 stairs • Elderly on anti-coagulant therapy • Motor bikes/cycle/water ski
	Horse	•

		Any horse-related injury
	Assaults	• Shooting • Stabbing • Focal blunt head trauma with GCS <13
	Multiple casualties	• With significant injuries
	Other	• Explosion • Hanging •

		Submersion
Injuries	• Potential airway obstruction/respiratory distress • Penetrating injury to the head/neck/chest/abdomen/pelvis/back/limbs • Paralysis (spinal cord injury) • Burns >10% BSA	
Signs	• Respiratory rate <10 or >30 • Heart rate <40 or >120 • Arterial pressure <90 systolic at any stage	

	• Capillary return >2 s • GCS <14
Treatment	• Multi-trauma transferred from other hospital within 24 h of injury • Intubation or assisted ventilation • >2 litre of fluid resuscitation

- Open table in a new tab

The team leader must check that the resuscitation is proceeding satisfactorily, decide which additional tests should be done, and formulate a definitive plan. Leadership skills have shown to be of particular importance: in situations where a command physician is clearly identified, there usually is a shorter time to primary and secondary survey and to performing diagnostic investigations.
[21] A study performed by Lubbert and colleagues in 2009

[24]

showed that efficient leadership was associated with a lower total number of deviations from ATLS protocol. Studies comparing surgeons with non-surgeons in the role of trauma team leader show no difference in predicted survival or ED length of stay.

Several studies have shown that the availability of an attending trauma surgeon on the trauma team 24 h a day reduces resuscitation time and time to incision for emergency operations, but has not demonstrated an impact on mortality.

Besides leadership, other human factors such as communication, supervision, and seeking help are important. These human factors could influence team structure and collaboration,

effectiveness during resuscitation,

[32]

and leadership attributes

[33]

and they could potentially influence clinical outcome factors. Understanding the role of trauma team members

[34]

and human factors may impact the clinical outcome of trauma patients.

[35]

The effects of the introduction of trauma teams

The aim of establishing a trauma team is to ensure the early mobilization and involvement of more experienced medical staff and thereby to improve patient outcome. Although it is difficult to separate the benefits of a trauma team from the effects of implementation of trauma systems, there is evidence that the introduction of trauma teams has improved patient outcome. Data from Petrie and colleagues [36] showed that patients with an injury severity score (ISS) >12 had a significantly better outcome when a trauma team was activated than when they were treated on service-by-service basis. Not only was the performance better when the trauma team was involved in the management of moderately to severely injured patients, there were significantly more unexpected survivors as well, even though both groups had access to the same personnel, imaging techniques, operating theatres, and intensive care unit in the same tertiary care centre.

The introduction of a trauma team in a level I trauma centre led to a significant improvement in triage time for all patients leaving the ED. Furthermore, it resulted in a trend towards lower overall mortality rates and mortality rates among patients with severe head injury. [37] A significant reduction in overall mortality rate, from 6.0% to 4.1%, was seen in another study; in patients who were most severely injured with an ISS of 25 or greater, mortality rates decreased from 30.2% to 22% (8.3% absolute reduction in mortality, 95% confidence interval 2.1–14.4%). [38] In patients who meet well-established trauma call criteria who are not treated by a trauma team, a higher mortality has been demonstrated. [39]

The horizontal approach of trauma team assessment and resuscitation of patients may lead to a reduction in time from injury to critical interventions. A decrease in time to definitive care, for instance, time to haemorrhage control or neurosurgical interventions, may have an impact in mortality. A well-organized trauma team has been shown to carry out a complete resuscitation in a mean of 56 min rather than 122 min, more than halving the total resuscitation time.
[12]

A study in our institution demonstrated an even shorter total trauma room time of 33 min.
[24]

Trauma training

ATLS course

The first ATLS course was in 1978. The course was adopted by the American College of Surgeons (ACS) Committee on Trauma and incorporated as an educational programme 1 yr later. In that same time period, area-wide medical emergency systems were implemented and the development of trauma teams gained more attention. A group of local surgeons and physicians, the Lincoln Medical Education Foundation, together with University of Nebraska Medical Center and the Nebraska State Committee on Trauma (COT) of the ACS, founded courses to improve the quality of ATLS skills.
[40]

Originally, the ATLS course was developed for doctors in rural areas who did not manage trauma patients on a regular base. The ACS expanded the ATLS course nationally in 1980. The first pilot courses seemed to show an improvement of outcome of trauma patients in rural areas.

ATLS courses are nowadays very common and widely accepted and have resulted in better outcome as was shown in several studies.

Ali and colleagues showed that an ATLS programme for physicians resulted in a statistically significant improvement of in-hospital trauma patient outcome (observed to expected mortality ratio of 3.16 pre-ATLS compared with 1.94 post-ATLS). The same study group also showed a significant decrease in mortality and morbidity after instituting a prehospital Trauma Life Support (PHTLS) programme.
[45]

Simulation-based training

Simulation-based training (SBT) is focused on promoting expertise through simulation techniques. It creates a situation where skill development, practice, and feedback are applied and can take place in a replication of the real-world environment.
[46]

The current review will focus on the teamwork aspect of SBT. Shapiro and colleagues
[47]
concluded in 2004 that high-fidelity medical simulation training appeared to be a promising didactic teamwork training method. After an intervention study using a pre- and post-training design, it was clear that there were significant improvements in different domains using the Trauma Team

Performance Observation Tool (TPOT). These included improvements in the domains of leadership (P=0.003), situation monitoring (P=0.009), mutual support (P=0.004), communication (P=0.001), and overall (P<0.001). The times from arrival to the computed tomography (CT) scanner (26.4–22.1 min, P=0.005), and the operating theatre (130.1–94.5 min, P=0.021) improved significantly.
[48]

Another pre- and post-intervention study showed significant improvements in the objective variables of resuscitation time (<0.05), T-NOTECHS scores (<0.05), and frequency of near-perfect task completion (<0.001).
[49]

The T-NOTECHS score is a modified non-technical skills scale for trauma and is developed to assess teamwork skills of multidisciplinary trauma resuscitation teams. Miller and colleagues
[50]
concluded that *in situ* trauma simulation (ISTS) improved performance during the period when the training had taken place, especially teamwork and communication skills compared with the period before the ISTS, but that the effect was not sustained when the ISTS training stopped. The scores measured in the period between 1 and 5 weeks after the last ISTS session were similar to the baseline scores. In conclusion, the effect of stimulation training has positive outcomes on team performance, although it is questionable what the long-term effects are. Consequently, it seems to be important that trauma teams train on a regular basis, if the effects of training are to be sustained.

There are many different modalities available for SBT. The diverse range of medical-simulation modalities enables trainees to acquire and practice an array of tasks and skills.[51] There is little evidence as to which modality has the best outcome. A study by Wisborg and colleagues[52] concluded that there seems to be no difference in outcome in between stimulation using a mannikin or standardized patients when the educational goal is training communication, co-operation, and leadership within the team. A critical note, however, is that the outcome is measured in participants' assessment of their educational outcome and the degree of realism instead of a more objective outcome score.

Video review

Studies have been published describing the videotaping and review of both simulated and actual trauma resuscitations. Video recording of trauma resuscitations can serve three goals. First of all, evaluation of trauma resuscitations can be of use for educational purposes. Videotaping real trauma resuscitations with subsequent review creates the opportunity to modify behaviour by analysing resuscitation performance in a more controlled format with more experienced physicians. Secondly, video registration can serve as a tool for quality assessment, for instance, to monitor adherence to ATLS guidelines.[53] Finally, the video registration data can be used for research purposes.

Hoyt and colleagues[54] were the first to describe the use of video review of trauma team resuscitations. They evaluated 2500 resuscitations in a 3.5 yr period. The resuscitations were reviewed using an audit form and discussed during a conference attended by various members of the trauma team, including prehospital personnel, radiology, respiratory therapy, doctors, nurses, and students. The review process produced an overall 12% reduction in resuscitation time during a 3 month resident rotation. When stratified for injury severity, the group with an ISS>20 had a reduction in resuscitation time of 15%, compared with a 9% reduction in patients with an ISS<20. A greater benefit for more severely injured individuals was also shown by Townsend and colleagues[55] in a similar study.

In order to pursue quality improvement using video recording of trauma resuscitations, an objective evaluation system is required. Written guidelines must direct reviewers through the tape and remove subjective evaluation of events.[56] Besides evaluation of objective data, such as adherence to ATLS protocols and total resuscitation time, videotape review can be used to assess teamwork and leadership.[53] In order to improve trauma teamwork, a tool to accurately capture and assess the important factors of trauma resuscitation has been developed.

[57]

This tool was developed on the basis of five behavioural domains, which had been used to evaluate non-technical skills (NOTECHS) in the operating theatre. Inter-rater reliability was evaluated using video review of team training using simulated scenarios and actual resuscitations. Although further work to improve inter-rater reliability is warranted, the clinical relevance of the tool was suggested by improvement of the scores after teamwork training, and correlation with clinical parameters in simulated and actual trauma resuscitations.

Scherer and colleagues

[58]

showed an improvement in half of the behaviours studied within 1 month of initiating conference-based video review, compared with no improvements after 3 months of verbal feedback. Video data are objective evidence of an individual's performance. Enabling colleagues to understand their performance is the first step in effecting a change in behaviour. It can also be helpful in identifying incongruities in perceived self-efficacy, which is the discrepancy between the behaviours the participants think they are performing *vs* the behaviour they actually perform.

The future of trauma teams

So far, we have discussed the institution and development of trauma teams and described the current situation. In the latter part of this article, we will discuss the future of trauma care and its impact on the trauma team.

Radiology

The CT has become an important diagnostic tool in trauma care. In many trauma patients, a clear history is not available and physical examination can be misleading

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or equivocal.

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Furthermore, it is not possible to exclude abdominal or pelvic organ injury based on clinical examination.

61

Therefore, diagnostic imaging has become a widely accepted standard for management of polytrauma patients. Sonography is usually readily available in the ED and the FAST is used as initial screening. It has a high positive predictive value for detection of free fluid, but a low sensitivity. CT is the modality of choice in order to detect visceral injuries and determine the extent of blunt abdominal trauma.

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The advantages of the CT are clear: not only does it provide more complete information regarding the abdomen, it also allows for rapid examination of the head, neck, and chest.

64

Several large series have shown the effectiveness of targeted CT in management of haemodynamically stable patient with blunt abdominal or thoracic trauma.

A more recent study demonstrated a significant increase in survival in haemodynamically unstable major trauma patients receiving a whole-body CT scan as well, if performed quickly within a well-structured environment and by a well-organized trauma team.

69

This is a remarkable result, even though it was a non-randomized retrospective study. Furthermore, there were more than 300 patients who did not receive a CT scan due to emergency surgery. Resuscitation should still be physiology-driven and in patients with severe instability, emergency surgery precedes radiological evaluation. However, since CT scanning is generally available in or close to the trauma room; it can be used early in the resuscitation phase and thus may lead to a better survival of trauma patients. CT scanning may have potential in the prehospital phase; indeed, it is currently in use in stroke patients enrolled into a pilot study in Germany.

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This development in imaging could have an impact on trauma team composition. CT has a high sensitivity for the detection of parenchymal injuries and a good sensitivity for injuries of the gastrointestinal tract, provided that adequate examination technique and careful diagnostic interpretation is combined.

64

The radiologist should thus be a regular member of the trauma team to aid in quick and thorough interpretation of the CT images. Moreover, in addition to aiding with diagnosis, the interventional radiologist will be increasingly involved in the treatment of trauma patients. A growing number of hospitals are equipped with a hybrid operating theatre facilitating combined surgical and endovascular treatment of trauma patients.

Shock management

Changing insights into coagulation pathophysiology have driven the demand for earlier and different diagnostic technologies such as thromboelastography, and point-of-care testing. Coagulation therapy continues to evolve and may also influence future trauma team composition.

Trauma-induced coagulopathy is well known in severely injured patients and was first recognized during the Vietnam War.

Coagulopathy after trauma is common and was previously attributed to iatrogenic causes such as dilution from i.v. fluid therapy, massive blood transfusion, and other factors such as progressive hypothermia, and acidosis.

While these factors should not be neglected, we now know that acute traumatic coagulopathy (ATC) is an independent predictor of mortality.

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In 56% of trauma patients, abnormal coagulation is present in the first 25 min after injury.

80

In the last decade, we have developed a better pathophysiological understanding of ATC. Key characteristics of ATC are isolated factor V inhibition, dysfibrinogenaemia, systemic anticoagulation, impaired platelet function, and hyperfibrinolysis.
[81]

In addition, activation of protein C due to endothelial disruption is likely to cause coagulation factor consumption and loss of inhibition of fibrinolysis.
[82]

[83]

ATC can be exacerbated by hypothermia, acidosis, and resuscitation with hypocoagulable fluids.
[81]

Increasing injury severity is associated with increasing likelihood of an abnormal coagulation test (ISS 9–16: 5%; ISS 17–25: >10%; ISS >45: 43%). Mortality due to severe injury and coagulopathy occurs quickly. The mean time to death for trauma patients who die of uncontrolled haemorrhage is 2 h
[84]

and more than half of all injured civilians, in rural areas up to 80%, who die from their injuries die in the prehospital phase.
[85]

[86]

It is increasingly recognized that blood and coagulation management is an important aspect of the early treatment of severely injured trauma patients.

Massive haemorrhage requires massive transfusion to maintain adequate circulation and haemostasis.

87

Current data support that trauma patients treated with higher ratios of plasma and platelet to red blood cell transfusions have improved outcomes, but further clinical investigations are needed.

87

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In cases of massive transfusion, a well-defined protocol helps to delineate how blood products are ordered, prepared, and delivered; determine laboratory algorithms to use as transfusion guidelines; and outline duties and facilitate communication between involved personnel. The development of such a protocol is a joint responsibility of members of the trauma team and a hospital transfusion team.

The improved understanding of ATC and the institution of mass transfusion protocols may have an impact on the operative treatment of trauma patients. Administration of blood products early in the resuscitation could lead to less haemodynamic instability and thus decrease the number of patients requiring damage control surgery, since damage control management is focused on a haemodynamic stable patient before definitive surgical treatment. This could therefore mean that early total care could be possible for more trauma patients and secondary and tertiary surgical treatment can occur sooner, or even in one session.

Conclusions

Trauma patients benefit from resuscitation by a trauma team because of the rapid resuscitation and stabilization and reduction in time to diagnostics and treatment. The team leader must oversee the resuscitation and intervene when necessary. Leadership skills have shown to be of particular importance. Resuscitation should be physiology-driven and the patients' response to resuscitation determines further treatment, which can vary from damage control surgery to observation.

Definition of damage control surgery

- Rapid termination of an operation after control of life-threatening bleeding and contamination followed by correction of physiologic abnormalities and definitive management.

Key principles:

- Control of haemorrhage
- Control of contamination
- Use of temporary shunts to bypass ligated vascular injuries
- Delay of abdominal closure, or temporary wound closure
- Staged definitive procedure

Rationale for damage control surgery and delay of definitive management

Historically, much of the mortality and morbidity from trauma was associated with the early attempt at repair. Attempts were made to complete the definitive management early, in the first operation. The repair attempts turned into prolonged procedure,s lasting many hours. Frequently such rescues were attempted by teams composed of mainly junior staff, and out of normal working hours. Attempts to subject unstable trauma patients to these "classical" long laparotomies were frustrated by failure. This is because hypothermia, acidosis, and coagulopathy render attempts at definitive surgical repair less likely to succeed. Thus, the rationale for damage control surgery is early surgical control of immediately lifethreatening injuries and the establishment of haemostasis. Definitive management can be delayed in most cases; the patient can spend some time in ICU getting their physiology un-deranged. Definitive management can take place safely (and is more likely to succeed) once the physiological abnormalities are corrected. The timing can be negotiated with the surgical teams, so that the optimum level of expertise can be present.

This has had a marked effect on mortality. The first publication on this topic (Stone et al, 1983) offers a nightmarish glimpse of the bloodied hell-scape that was early trauma surgery. Thirty one patients who developed lethal coagulopathy in theatre were enrolled. Of the "traditional" surgical approach, the mortality rate was 98%. The others were quickly clamped and packed, and taken to ICU with their abdomens open. Their return to theatre was dictated by the resolution of their coagulopthy. The abdominal packs were left in for an average of about 27 hours; then definitive management took place.
The mortality rate from this was 35%.

Indications for damage control surgery

I was able to find this list of indications in Godat's 2013 position paper. It, in turn, draws on Rotondo and Zonies' "The damage control sequence and underlying logic" (1997). In trauma patients, the pre-operative indications include the following:

- Specific injury patterns which favour DCL:
  - Penetrating injury
  - Gun shot wound
  - High-energy blunt torso trauma
  - Major abdominal vascular injury
  - Multicavitary exsanguination
- Systolic blood pressure (SBP) <90 mmHg.
- Need for re-suscitative thoracotomy.
- Hypothermia (≤33°C)
- inappropriate bradycardia
- pH of <7.2
- Transfusion of more than 10units of PRBCs
- Total fluid replacement >12 L
- Estimated blood losses of ≥ 5 L

Temporary abdominal closure (TAC) methods:

- From Godot, *"The ideal TAC should be easily and quickly applied, allow room for expansion, limit contamination, decrease bowel edema, protect the viscera, fascia and skin from damage, evacuate fluids, prevent adhesions, minimize loss of domain and be cost-effective".*
- First TAC experiments ghad patients with intra-abdominal packs termporarily half-closed with towel clips or runing sutures. Abdominal

compartment sydnrome was the cvonsequence. This practice has since been abandoned.

- Later, some sort of erzats water-impermeable barrier was used (eg. a disembowelled IV bag or stoma bag). But, it was *sutured directly to the skin*. Again, abdominal compartment syndrome developed in up to 33% of patients because the abdomen was technically still "closed".
- Vacuum-assicted closure devices are used most frequently today. They consist of packing sponged and an occlusive surface dressing. There is much less abdominal compartment pressure problems with these. But, there are occasional issues with enterocutaneous fistula. The rates of this complication vary from 1.5 to 15% in the literature.

Complications upon returning to the ICU:

Remember that the patient was not being definitively managed in theatre; if you are lucky they are bleeding slightly less than they were before they went to theatre, but in general the resuscitation is only half-complete. Not only that, but they were probably rushed through the ED, and a secondary survey (or trauma CT) may not have been performed.

Thus, one can anticipate the following:

- Old, uncontrolled traumatic bleeding
- New, uncontrolled surgical bleeding
- Uncontrolled coagulopathy, hypothermia and acidosis
- An open abdomen (thus, high sedation and analgesia requirements)
- Abdominal compartment syndrome (if they decided to close it)
- Missed injuries

Principles of ICU management between stages of surgical repair

While recovering from one horrendoplasty and while waiting for the next one, the ICU team has several jobs to do. The emphasis for rescuing the patient has shifted from ED procedures (who now merely triage the trauma) and from the surgical team (who do a quick clamp-and-burn). Now, the ICU is in charge of the bulk of the resuscitation, which - some might argue - is how it should be.

An excellent 2006 article by Sagraves et al ("Damage control surgery—the intensivist's role") does this topic justice with the appropriate amount of detail. The domains of ICU management can be discussed in a familiar sequence, starting with the airway.

A. Keep them intubated. There is no rush to get the tube out.
B. Ventilate with lung-protective strategy.
   The compliance will be poor for a number of reasons (eg. fluid excess, lung contusion, massive distended abdoimen, and so forth).
C. Correct hypovolemia; use lactate to determine the effectiveness of resuscitation.
   Vasopressors will not be helpful (the SVRI is already very high due to the endogenous catecholamine surge)
D. Sedate and paralyse. No coughing is permitted. This improves the integrity of the open abdomen dressing, improves chest wall compliance and protects you from abdominal compartment syndrome.
E. Electrolytes may be deranged; specifically, one ought to obsess over the calcium, which is a necessary cofactor in clotting.

Rewarming and correction of acidosis are essential part of resuscitation.

F. One must remember to measure the CK. In a major trauma, as attention ends up focused on the abdomen, everybody forgets about the compartment syndrome of a compromised limb, and rhabdomyolysis ensues.

G. It would not be wise to start either TPN or NG diet at this stage, particularly if the bowel has been left disconnected. One may wait until after the definitive surgery.

H. **Correct the coagulopathy**. One may consider using Factor VII off-label for this.

I. Antibiotics are indicated; the wounds are usually contaminated.

OVERVIEW

- Damage control surgery, along with permissive hypotension and hemostatic resuscitation, is integral to the concept of damage control resuscitation
- Damage control surgery involves limited surgical interventions to control haemorrhage and minimize contamination until the patient has sufficient physiological reserve to undergo definitive interventions
- This strategy was derived from military experience and is now increasingly adopted into civilian trauma management

DAMAGE CONTROL RESUSCITATION

- Damage control resuscitation (DCR) is a systematic approach to the management of the trauma patient with severe injuries that starts in the emergency room and continues through the operating room and the intensive care unit (ICU)

- DCR involves haemostatic resuscitation, permissive hypotension (where appropriate) and damage control surgery
- DCR aims to maintain circulating volume, control haemorrhage and correct the 'lethal triad' of coagulopathy, acidosis and hypothermia until definitive intervention is appropriate

RATIONALE FOR DAMAGE CONTROL SURGERY

- Management of the metabolic derangement of ongoing bleeding supersedes the need for definitive surgery
- Abbreviated operations that control haemorrhage and contain spillage from the alimentary and urogenital tracts
- Rapid transfer to ICU for correction of acidosis, coagulopathy and hypothermia (ongoing haemostatic resuscitation)
- Definitive operation is deferred
- These operations tend to have a high complication rate
- Survival is given preference over morbidity

Benefits

- maintenance of normothermia
- less coagulopathy
- fewer products used overall, despite increase in pre- and intra-operative blood product use
- may produce decreased ALI, MODS, ARDS and improve survival

STAGES OF DAMAGE CONTROL RESUSCITATION

Recognition

- must be approached from all services (pre-hospital, ED, anaesthesia, surgery, ICU, haematology)

Haemostatic resuscitation

- early transfusion to maintain circulating volume
- minimisation of crystalloid use
- reduce coagulopathy
- keep warm
- prevent acidemia

Rapid movement to the operating theatre (OT)

- “scoop and run” approach
- address immediate life threats prehospital or in the emergency department
- permissive hypotension may be tolerated in penetrating vascular trauma pending surgical repair
- avoid unnecessary delays in transit to the OT

Initial surgery

- short time in OT
- limited focused surgery to control haemorrhage and decontaminate
- pack
- partially resect organs
- staple off and remove injured bowel
- fibrin sealants
- leave abdomen open

Move to ICU

- restore near normal physiology

- correct lethal triad: rewarm, correct acidosis and correct coagulopathy
- optimize ventilation
- plan re-operation once stable

Re-operation at 24-36 hours

- remove packs
- definitive surgery
- formally close abdomen

COMPLICATIONS

- new onset or uncontrolled surgical bleeding
- abdominal compartment syndrome
- inability to wake and wean
- non-life threatening injuries not dealt with or missed (needs secondary survey/full examination)

Trauma & the Triad

Despite great advancements in trauma care over the past 30 years, trauma is still one of the leading causes of death in any age group. This is especially apparent in the young–for those aged 1—44 years old, trauma is the No. 1 cause of death in the United States.1 Of these deaths, hemorrhage accounts for up to 40% and remains as the leading preventable cause of trauma-related death.2,3

The lethal triad of hypothermia, acidosis and coagulopathy has been recognized as a significant cause of death in patients with traumatic injuries. In 1982, a study described a “bloody vicious cycle”• in which hemorrhage and tissue injury cause this predictable triad of complicating factors.4 Ultimately, this triad resulted in worsening hemorrhage and eventual death. Authors of the research suggested treatment of hypothermia, acidosis and coagulopathy in trauma requires as much attention as the traditionally emphasized surgical management of injuries.4

Today, we recognize that to successfully resuscitate the critically ill trauma patient, all emergency providers must have a firm understanding of the lethal triad. This understanding should serve as the cornerstone for all interventions provided to the bleeding trauma patient. Left untreated, hypothermia, acidosis and coagulopathy bring about and propagate each other, eventually resulting in a predictable but irreversible progression toward death.

Hypothermia

Normal human body temperature is 35.6—37.8 degrees C with hypothermia being defined as a core temperature < 35 degrees C.5 In one study, it was found that almost half of EMS-transported trauma patients had a temperature < 36 degrees C on arrival to the ED.6 Important to note is that there was no association between season of the year and frequency of hypothermia. At highest risk were those patients older than 65 and those who had been entrapped.6 In addition, hypothermia in trauma has been associated with a significantly increased mortality compared to patients with the same body temperature from environmental exposure alone. In a study of 71 trauma victims, a core temperature < 32 degrees C was associated with 100% mortality independent of the presence of shock, injury severity or volume of fluid resuscitation.7 Because hypothermia in a trauma patient predicts such a poor outcome, the traditional classification system of hypothermia has been revised for use in this vulnerable patient population. (See Table 1–below.)

Even mild hypothermia in a trauma patient can result in devastating physiologic consequences. (See Table 2.) Of particular concern is the effect of hypothermia on the coagulation system.8 The coagulation system is a temperature- and pH-dependent series of complex enzymatic reactions that result in the formation of blood clots to stop both internal and external hemorrhage.

Coagulopathy is the term used to describe a broad group of disease states in which there is an impaired ability of this coagulation system to synthesize blood clots.5 It’s been repeatedly demonstrated that as a patient’s core temperature decreases, so does the body’s ability to stop bleeding. This is a result of impaired platelet function, inhibition of the clotting factors, and inappropriate activation of clot breakdown.8

Hypothermia in trauma patients is caused by a multitude of factors. Hemorrhagic shock, traumatic brain injuries, and alcohol intoxication impair the body’s ability to regulate its core temperature.8 In addition, patients at the extremes of age and those with certain medical conditions such as diabetes or thyroid disease are at higher risk to develop hypothermia after trauma.8 Furthermore, those patients with prolonged exposure to the environment as during an extrication and those with severe burns are at risk for rapid heat loss causing profound hypothermia.

Lastly, an important care consideration for a trauma patient is the temperature of the fluids and blood products we infuse as well-intentioned therapy. Room temperature normal saline (20—25 degrees C) is very hypothermic relative to the desired normal body temperature. Thus, large volume resuscitations with even room temperature IV fluids can significantly contribute to this arm of the lethal triad.

Acidosis

A pH level is a measure of the blood's acidity on a scale of 0—14; water has a "neutral"• pH of 7.0. A healthy individual maintains a physiologically normal pH of 7.35—7.45 through a complex balance of hydrogen ions (acids) and buffers predominately controlled by the pulmonary and renal systems.

Acidosis is defined as an arterial pH < 7.35 and can result from a variety of disease states. However, in trauma patients the major contributor is poor perfusion to the tissues. Anemia from acute blood loss, peripheral vasoconstriction in response to hypothermia and blood loss, and overall decreased cardiac output severely impair oxygen delivery to the tissues. This results in tissue oxygen demand far exceeding oxygen delivery. Thus, to make functional energy, the body's cells are forced to utilize anaerobic metabolism instead of the normal aerobic metabolism, resulting in the production of lactic acid as a byproduct.9

As a trauma patient's perfusion worsens, lactic acid rapidly accumulates in the tissues. This causes the body's pH to drop, resulting in a severe metabolic acidosis. It's important to note that this process frequently occurs in the presence of normal or only slightly abnormal vital signs.

An additional cause of acidosis in the trauma patient is excessive resuscitation using unbalanced crystalloid solutions such as normal saline.10 With a pH around 5.5, normal saline is far more acidic than the desired normal blood pH. In large-volume resuscitations, normal saline predictably causes its own metabolic acidosis as a result of the high chloride content.11 Thishyperchloremic metabolic acidosis only serves to compound the existing lactic acidosis of trauma. Furthermore, there's evidence that excessive use of normal saline with its high chloride content may increase systemic tissue inflammation and thereby contribute to the coagulopathy of trauma.11 Lactated Ringers (LRs) is an imperfect substitution: Although its pH is 6.5, LR contains lactate and is incompatible with many medications and blood products.

Lastly, a trauma patient may also have respiratory acidosis. This is a result of hypoventilation due to respiratory depression or obstruction resulting in hypercapnia (increased CO_2 levels). Common causes of a respiratory acidosis in trauma include narcotic or alcohol use, traumatic brain injuries, flail chest or preexisting medical conditions such as chronic obstructive pulmonary disease.

With severe acidemia ($pH < 7.20$), disastrous consequences can occur.12 (See Table 3.) For the trauma patient, one of the most harmful effects is that their coagulation system can become severely impaired. In one study, the function of part of the coagulation system was reduced by 55—70% when the pH dropped from 7.4 to 7.0.13

Coagulopathy

Coagulopathy can occur for a number of reasons; however, regardless of the specific cause, coagulopathy results in the potential for continued hemorrhage in the bleeding trauma patient.

Coagulopathy in trauma is a common occurrence, present in nearly one in four severely injured patients arriving at the ED. Furthermore, its presence is associated with a four-fold increase in mortality.14—16 The coagulopathy of trauma occurs not only because of hypothermia and acidosis as previously discussed, but also as a result of losing clotting factors through hemorrhage and hemodilution, and the body's use and subsequent depletion of both platelets and clotting factors.9

Dilutional coagulopathy occurs when we resuscitate a bleeding trauma patient with fluid or blood products that don't contain the same clotting factors lost in the acutely hemorrhaged whole blood.10 Crystalloids such as normal saline and packed red blood cells dilute the remaining clotting factors circulating in the trauma victim's blood. Furthermore, in the critically injured, through a complex series of enzymatic reactions, the clotting cascade can become abnormally activated, causing excessive clot formation and subsequent breakdown (fibrinolysis) out of proportion to the injury.9 This abnormal and excessive activation of the coagulation system rapidly consumes the body’s remaining clotting factors, resulting in a further deficiency of the essential factors needed to achieve hemorrhage control.

Lastly, EMS providers should be aware of those trauma patients who have a baseline coagulopathy because of preexisting medical conditions. Examples include those patients on anticoagulant therapy such as warfarin (Coumadin) or a novel oral anticoagulant such as dabigatran for stroke prevention in the setting of atrial fibrillation. These patients and those with chronic liver or renal failure have an increased risk of developing a truly life-threatening coagulopathy and hemorrhage after trauma.17

EMS Management of the Lethal Triad

There are several simple steps providers can and should follow to battle the lethal triad.

1. The triad begins and ends with bleeding, so find the bleeding and stop it. Hold pressure, use combat gauze, apply a tourniquet, bind the pelvis, etc. (See the article “Training & speed are crucial: Options, issues & training to prevent death from massive blood loss,”• by Joe Holley, MD, FACEP, in the JEMS December 2013 supplement, Putting the clamp on hemorrhage: How a simple, effective point-of-injury tool will transform the way bleeding is controlled in the field.)
2. Do not stop your search for bleeding with the first source you find, as others may exist.
3. Always assume your patient’s temperature is dropping right before your eyes, because it is, and much faster than you’d expect.
4. “Strip “˜em and flip “˜em,”• but not with reckless abandon. Make every

effort to expose only those body parts you're examining in the moment and keep the remainder of the patient covered.

5. Patients can and will become hypothermic in conditions you consider warm. Prioritize limiting a patient's exposure to the environment, especially during prolonged extrications.

6. Place a warm blanket between the newly extricated patient and your cold, hard backboard.

7. Turn up the heat in your ambulance. If you aren't sweating, it's certainly not warm enough. (Ideally, 27 degrees C.)

8. Promptly remove wet or bloody clothes and replace with a warm blanket. Shivering wastes valuable cellular energy and oxygen in an attempt to stay warm while producing more lactate, contributing to acidosis.

9. We don't bleed normal saline, so limit crystalloid infusion as much as possible. It contributes to the patient's acidosis and dilutes the remaining clotting factors in your patient's blood. IV fluids may improve a number, but may actually hurt your patient in the long run.

10. Except in those patients with a traumatic brain injury, utilize a permissive hypotension resuscitation strategy. Our goal should be to maintain tissue perfusion typically defined as the presence of a radial pulse or normal mental status. We should avoid overly aggressive fluid administration to normalize blood pressure, which can "pop the clot"• and worsen hemorrhage. (See "Vital pathways: Detect & treat symptoms related to hemorrhagic shock,"• by Peter Taillac, MD, FACEP and Chad Brocato, DHSC, CFO, JD, from the JEMS October 2012 issue and "Add a little salt: Permissive hypotension in trauma resuscitation,"• by Jeff Beeson, DO, FACEP, EMT-P and Trenton Starnes, NREMT-P in the JEMS April 2013 issue.)

11. Whenever possible, administer only warmed fluids. (Ideally 40 degrees C.)

12. Measure prehospital lactate levels when available to more accurately detect cryptic shock in trauma patients with normal vital signs. End-tidal carbon dioxide may also be a useful marker.

13. Monitor and maximize oxygenation.

14. Treat causes of hypoventilation to prevent a respiratory acidosis.

15. Identify high-risk patients with a baseline coagulopathy due to medications or preexisting medical conditions.

16. Administer tranexamic acid (TXA)–an antifibrinolytic that prevents clot breakdown and thus decreases blood loss–if your system permits its use. TXA has been shown to decrease mortality in two large trauma studies. (See "TXA: A difference-maker for trauma patients? Role of tranexamic acid in EMS & preoperative trauma management,"• by Jeffrey M. Goodloe, MD, NREMT-P, FACEP; David S. Howerton, NREMT-P; Duffy McAnallen, NREMT-P and Howard Reed, NREMT-P, in the JEMS April 2013 issue.)

Go to:

INTRODUCTION

Massive blood loss is encountered in various situations like polytrauma, major surgeries, gastrointestinal bleeds, obstetric haemorrhage, etc. Timely recognition and efficient management are vital for successful outcomes after major blood loss. American College of Surgeons National Surgical Quality Improvement Program database over 3 years revealed very low incidence of massive transfusion. However, it was associated with high mortality as compared to patients without transfusion. Nonfatal complications such as respiratory and renal, were seen in more than 50% of patients when more than 5 units were transfused.[1] In an analysis of haemorrhage claims in the United States Anaesthesia Closed Claims Project database for claims between 1995 and 2011, the authors note that anaesthesia care was more often assessed as less than appropriate.[2] Anaesthesiologists and other acute care physicians should, therefore, be well versed in the current concepts in the management of massive blood loss and transfusion.

Go to:

DEFINITION OF MASSIVE BLOOD TRANSFUSION

Various definitions of massive blood transfusion (MBT) have been published in the medical literature such as:[3,4,5]

- Replacement of one entire blood volume within 24 h
- Transfusion of >10 units of packed red blood cells (PRBCs) in 24 h
- Transfusion of >20 units of PRBCs in 24 h
- Transfusion of >4 units of PRBCs in 1 h when on-going need is foreseeable
- Replacement of 50% of total blood volume (TBV) within 3 h.

The definitions that use the period of 24 h are not useful during active management of blood loss. Furthermore, when used to identify MBT cases for observational studies, they dilute the data by selecting out early deaths. Therefore, the dynamic definitions, which identify rapid blood transfusions are better suited for use in day-to-day practice.

Data regarding MBT in the paediatric population is scarce. Definitions of MBT suggested for use in children are transfusion of >50% TBV in 3 h, transfusion >100% TBV in 24 h or transfusion support to replace on-going blood loss of >10% TBV/min.[6]

Go to:

PRINCIPLES OF MANAGEMENT OF MASSIVE BLOOD LOSS

Management of intravascular volume loss

a. This is a vital component of blood loss management. Physiologically, haemodynamic compensatory mechanisms maintain vital organ perfusion till about 30% TBV loss,[7] beyond which there is risk of critical hypoperfusion. Inadequate resuscitation at this stage leads to shock. Management of haemorrhagic shock is described elsewhere in this issue.

b. It is important to remember that overzealous resuscitation leading to high arterial and venous pressures may be deleterious as it may dislodge haemostatic clots and cause more bleeding.[8]

Management of loss of blood components

Blood component loss during massive blood loss is best managed by following the massive transfusion protocol (MTP). Mild to moderate blood loss can be managed with crystalloid or colloid infusions alone. However, with increasing loss, dilutional anaemia and later dilutional coagulopathy sets in. Also, plasma substitutes may have direct effects on the coagulation system particularly if used in volumes >1.5 L. In a study on surgical patients with normal coagulation factors, haemostatically critical levels of platelets ($50 \times 10^3/mm^3$), fibrinogen (1.0 g/L) and coagulation factor II, V and VII were reached at blood loss >200%, 150% and 200% respectively.[9,10,11] Therefore, it is generally recommended that replacement of blood components be guided by laboratory tests.[7] However in situations of large blood losses, the laboratory test based approach for replacement of coagulation factors may lead to a delay in the recognition and treatment of a rapidly developing coagulopathy as turnaround times for most laboratory tests is long. This may lead to catastrophic bleeding. A protocol based empirical replacement of coagulation factors is, therefore, recommended in massive blood losses.

Special considerations

a. Trauma: Acute coagulopathy of trauma shock is caused by a combination of tissue injury and shock, and may occur without significant fluid administration, clotting factor depletion or hypothermia[12,13]

b. Coagulopathy during cardio pulmonary bypass (CPB): Heparin given before CPB and hypothermia lead to platelet dysfunction that has been shown to be a major cause for bleeding in patients on CPB.[14,15] Extensive surgical trauma, prolonged blood contact with the CPB circuit, hypothermia and high doses of heparin lead to dysfunction of the coagulation and inflammatory systems further worsening the postoperative coagulopathy. In these cases, it is important to ensure adequate reversal of anticoagulants like heparin

c. Postpartum haemorrhage: Recent studies suggest that acquired fibrinogen deficiency may be the major coagulation abnormality associated with obstetric bleeding[16] which may be compounded by dilutional coagulopathy and hyperfibrinolysis.[17]

Go to:

WHAT IS MASSIVE TRANSFUSION PROTOCOL?

With better understanding of the pathophysiology of haemorrhagic shock, resuscitation of patients with massive haemorrhage has advanced from reactive, supportive treatment with crystalloid, PRBC, and laboratory report based use of coagulation factors, to use of proactive standardized protocols called MTPs. MTPs are designed to interrupt the lethal triad of acidosis, hypothermia and coagulopathy that develops with massive transfusion thereby improving outcome. MTP describes the process of management of blood transfusion requirements in major bleeding episodes, assisting the interactions of the treating clinicians and the blood bank and ensuring judicious use of blood and blood components. By developing locally agreed and specific guidelines that include clinical, laboratory, blood bank and logistic responses, clinicians can ensure effective management of massive blood loss and improve outcome.

Rationale for massive transfusion protocol

Physicians involved in managing war injuries noticed that early administration of fresh frozen plasma (FFP) during massive transfusion decreased coagulopathy and improved survival in patients. Aggressive management of injury-associated coagulopathy has been promoted in recent years in massive blood loss. Studies have shown improved survival using higher ratio of FFP to RBC transfusion as compared to the conventional approach.[18,19,20] Transfusing fresh whole blood would seem ideal but the time required to conduct safety tests on blood is long enough to cause significant depletion of coagulation factors. Therefore, administering RBCs, coagulation factors and platelets together maintains the physiological constitution of blood and prevents deficits of one or more constituents.

Massive transfusion protocols are activated by a clinician in response to massive bleeding. Generally this is activated after transfusion of 4-10 units. MTPs have a predefined ratio of RBCs, FFP/cryoprecipitate and platelets units (random donor platelets) in each pack (e.g. 1:1:1 or 2:1:1 ratio) for transfusion.[21,22] Once the patient is in the protocol, the blood bank ensures rapid and timely delivery of all blood components together to facilitate resuscitation. This reduces dependency on laboratory testing during the acute resuscitation phase and decreases the need for communication between the blood bank, laboratory and physician.

Limitations of massive transfusion protocols

1. Not standardised: The trigger for initiating the protocol as well as the optimum ratio of RBC: FFP: Platelets is controversial. Therefore practice varies from centre to centre.
2. Wastage: If MTP is triggered for a nonmassive blood loss situation, it may lead to wastage of blood products.

Other haemostatic/blood replacement strategies

1. Activated factor VII: The role of recombinant activated factor VII (rFVIIa) to manage uncontrolled bleeding is unclear. However, it can be considered as a rescue therapy in patients with life-threatening bleeding that is unresponsive to standard haemostatic therapy. When rFVIIa is used, the recommended dose is 200 μg/kg initially followed by repeat dose of 100 μg/kg at 1 h and 3 h[23]
2. Antifibrinolytic agents: Drugs like tranexemic acid may be useful in bleeding complicated by fibrinolysis such as cardiac surgery, prostatectomy etc.[24] Early administration of tranexamic acid in bleeding trauma patients has been shown to significantly reduce mortality[25,26]
3. Cell salvage: Can be extremely useful in unanticipated blood loss and in patients with rare blood groups. This strategy is generally reserved for massive blood loss in operation theatres as asepsis can be maintained easily. However, the relative contra indications such as a possibility of contamination with infected material and malignant cells should be considered.[27]

Go to:

COMPLICATIONS OF MASSIVE TRANSFUSION

Immediate

Problems secondary to volume resuscitation

a. Inadequate resuscitation: Hypoperfusion leads to lactic acidosis, systemic inflammatory response syndrome (SIRS), disseminated intravascular coagulation and multiorgan dysfunction. It also increases the expression of thrombomodulin on endothelium, which then complexes with thrombin, which in turn leads to a reduced amount of thrombin available to produce fibrin and increases the circulating concentrations of anticoagulant activated protein C, which worsens the coagulopathy

b. Overzealous resuscitation

   i. Transfusion Associated Circulatory Overload: This is a well-known condition that occurs due to rapid transfusion of blood or blood products. Though this is seen commonly in elderly patients, small children and patients with compromised left ventricular function, it can also be seen in patients requiring massive transfusion. In patients with haemorrhagic shock, crystalloids and colloids are used for initial resuscitation. When blood and blood products become available, patients are transfused with required components that may then lead to circulatory overload.

   ii. Interstitial oedema due to increased hydrostatic pressure which may lead to abdominal compartment syndrome.

Dilutional problems

a. Dilutional coagulopathy: During haemorrhagic shock, there is fluid shift from the interstitial to the intravascular compartment that leads to dilution of the coagulation factors. This is further accentuated when the lost blood is replaced with coagulation factor deficient fluids. Studies have also shown that infusion of colloids and crystalloids induce coagulopathy to a greater extent than that explained by simple dilution.[28,29,30]

b. Low colloid oncotic pressure giving rise to interstitial edema.

Problems related to transfusion of large volume of stored blood

a. Citrate toxicity: 80 ml of citrate phosphate dextrose adenine solution present in each blood bag contains approximately 3 g citrate. A healthy adult can metabolise this load in 5 min.[31] However, hypoperfusion or hypothermia associated with massive blood loss can decrease this rate of metabolism leading to citrate toxicity. Unmetabolised citrate can then lead to hypocalcaemia, hypomagnesemia and worsen the acidosis. Hypocalcaemia can lead to myocardial depression that manifests earlier than hypocalcaemic coagulopathy. Hypotension not responding to fluids should alert the physician to this complication. Calcium supplementation is thus required in most cases of MBT.

b. Hyperkalaemia: Potassium concentrations in PRBCs can range from 7 to 77 mEq/L depending on age of stored blood.[32] Development of hyperkalaemia will depend on the underlying renal function, severity of tissue injury and rate of transfusion. At transfusion rates exceeding 100-150 ml/min, transient hyperkalaemia is frequently seen.[33] Also, acidosis secondary to hypoperfusion may worsen hyperkalaemia. Cardiac effects of hyperkalaemia are accentuated by hypocalcaemia.

c. Hypothermia: Factors contributing to hypothermia include infusion of cold fluids and blood and blood products, opening of coelomic cavities and decreased heat production. Hypothermia leads to decreased citrate metabolism and drug clearance and more importantly, contributes to the development of coagulopathy. Slowing of enzyme activity and decreased platelet function individually have been shown to contribute to hypothermic coagulopathy at core temperatures below 34°C.[34] Coagulopathy due to hypothermia is not reflected in laboratory tests as the samples are warmed during processing.

d. Hypomagnesemia: Citrate also binds to magnesium and can lead to hypomagnesaemia which can further accentuate effects of hypocalcaemia. Infusion of large amounts of magnesium poor fluid can also contribute to hypomagnesemia.

e. Acidosis: After 2 weeks of storage, PRBCs have a pH below 7.0, and each unit has an acid load of approximately 6 mEq. One of these mEq of acid comes from the fact that PRBCs are made from venous blood with a starting pH of 7.35, a second mEq is acquired in buffering the citric acid in the anticoagulant, and 4 mEqs are generated by glycolysis during PRBC storage.[35] Acidosis directly reduces activity of both extrinsic and intrinsic coagulation pathways. A pH decrease from 7.4 to 7.0 reduces the activity of FVIIa and FVIIa/TF by over 90% and 60% respectively.[36]

Late complications

1. Respiratory failure

   Transfusion related acute lung injury (TRALI): The risk of TRALI increases with the number of allogenic blood and blood products transfused. The exact pathologic mechanisms of TRALI have not been clearly understood and both immunologic and nonimmunologic mechanisms have been suggested

2. SIRS
3. Sepsis
4. Thrombotic complications.

Preparation for massive bleeding

- Large bore intravenous (IV) access: Two peripheral IV (14/16 gauge) cannulae or special wide bore cannulae (insertion sheath) can be sited in neck veins such as the internal jugular vein. In emergency situations, canulation of external jugular vein may be considered
- Warming devices: In-line fluid warmers and surface warmers
- Continuous core temperature monitoring
- Invasive arterial pressure monitoring
- Adequate amount of colloid (gelatins), crystalloid, infusion sets and IV calcium preparations
- Communication with blood bank about emerging massive blood loss situation
- Adequate manpower for sending samples for investigations and getting blood and blood products

- Point-of-care testing is highly desirable: Arterial blood gas (ABG) and thromboelastograph (TEG). ABG with haemoglobin (Hb), electrolyte and lactate levels, repeated hourly, are useful in directing therapy
- Rapid infusion pumps or pressure bags to speed the fluid infusion rate
- Postoperative intensive care: Mechanical ventilation and continuous haemodynamic monitoring are usually required due to occurrence of circulatory overload and haemodynamic/biochemical instability.

Monitoring

Clinical monitoring: Electrocardiogram, capnometry, pulse oximetry, arterial blood pressure, core temperature, and urine output.

Invasive arterial pressure: Invasive arterial pressure measurement allows beat-to-beat pressure measurement and has greater accuracy than cuff based measurements in low flow conditions. Also, the arterial catheter allows frequent arterial blood sampling which is useful in guiding therapy. Many modern haemodynamic monitors calculate pulse pressure variation which is a more specific indicator of volume responsiveness.

Role of central venous pressure monitoring: Central venous catheters, due to their length and high resistance, allow inferior flow rates than wide bore cannulae. However, they are useful for assessment of the haemodynamic status, administration of vasoactive agents and blood sampling.

Laboratory monitoring: Laboratory values should be obtained frequently. Recommended lab tests include Hb, platelet count, prothrombin time, partial thromboplastin time (PTT), fibrinogen, potassium, ionized calcium, ABG for acid base status and central venous oxygen saturation/lactate as an indicator of tissue hypoperfusion.

Limitations of conventional laboratory testing: The time lag between collection of samples and obtaining the reports is a serious limitation in their utility during rapid on-going blood loss.

Role of point of care coagulation testing

Coagulation tests usually have long processing times and may not be helpful in guiding therapy in a rapid evolving blood loss situation. However, results may be useful later to assess how the case developed. Thromboelastography (TEG) is test of the visco elastic properties of blood that examines the entire haemostatic system including platelet function and fibrinolytic system and is particularly useful in complicated coagulopathies. Also, rapid availability of results helps in timely intervention.

Targets of resuscitation in massive blood loss

- Mean arterial pressure (MAP) around 60 mmHg, systolic arterial pressure 80-100 mmHg (in hypertensive patients one may need to target higher MAP)
- Hb 7-9 g/dl
- INR <1.5; activated PTT <42 s

- Fibrinogen >1.5-2 g/L
- Platelets >50 × 10^9/L
- pH 7.35-7.45
- Core temperature >35.0°C
- Base deficit <3.0/lactates <2 mEq/L.

Practical tips

1. Early recognition of massive blood loss and triggering MTP - prescribe blood and blood products early to allow for delivery time lag and thawing time (30 min for FFP)
2. Collect blood sample for cross match early as colloids may interfere with cross matching (mainly dextrans by coating RBC surface)
3. Inotrope/vasopressor drugs should only be used in a blood loss scenario during severe hypotension to avoid critical hypoperfusion and to buy time for fluid resuscitation. They should be stopped as soon as volume deficits are replaced, and a safe blood pressure is achieved.
4. Do not exceed recommended maximum doses of colloid. Also use of starch based colloid solutions in large volumes in a haemodynamically critical patient is controversial in view of evidence of renal dysfunction associated with their use in intensive care unit.[37]

Go to:

SUMMARY

Management of massive loss requires a quick concerted team effort by many medical and paramedical members. Understanding the complex pathophysiology of massive blood loss and its replacement is crucial to a successful outcome. Recent evidence supports early use of coagulation factors to improve outcome. Indian hospitals should formulate MTPs suited to their need and resources to improve survival in massive blood loss.

It is hoped that this document can lead to the development of further standard treatment guidelines for specific areas of trauma management for the Indian context. It seeks to improve the quality of trauma care services, intends to advocate for changes in health policy and decisions towards better outcomes for trauma. Trauma can occur to anybody, anywhere and therefore, it is imperative for a nation as large as ours to holistically work with the government and non-government organizations including all sectors of the society to bring awareness and management skills to every individual to handle a situation in a calm and accurate way. In view of the increasing burden of trauma in India and the rising cost of management of these patients, we would need to look into decreasing this burden and cost by a systematic management approach in each of the following parts: 1. Prevention if done properly, it would lead to more effectiveness with less expenditure. ● Implementation of rules during driving motored vehicles along with swiftness of penalty for disobeying it is must, like: ○ helmets even for bicyclists and a separate area for them ○ seat belts compulsory ○ speed limits and breaking signals to be taken seriously ○ driver education on basic first aid must be done in driving tests, etc) ● Proper checks and policing on alcohol and drug abuse in vehicle drivers. ● Road quality to be improved, especially in prone areas, like improving lighting, filling potholes. ● Access improved for health care facilities, especially in the rural areas of India ● Implementation of safety rules along with regular drills and checks in large organizations like factories, mines, schools, offices, hospitals, railway stations, etc ● Safety measures to prevent burns, falls, electrocution and prevention of railway accidents (simply closing the doors of local trains should be made compulsory). ● Identification of risks, research and injury surveillance projects to be undertaken regularly. ● Violence minimization in high risk groups like adolescents, alcoholics and drug abusers by awareness sessions to prevent them from entering into abusive relations with society and enabling them to make informed decisions ● Children, aged, mentally and physically challenged, and pregnant women are more prone to injury and hence, infrastructure should be made with them in mind. ● Awareness programmes to be increased using all forms of media to reach maximum population 2. Pre-hospital care - ● Training of paramedical staff to give life saving safe treatment en-route to hospital.

VALUE ADDED COURSE

COMPREHENSIVE TRAUMA LIFE SUPPORT

Annexure II

STUDENT ENROLLMENT LIST (JULY-DECEMBER 2019)

S.No.	University no	Name of the student	Year / CRRI	Signature
1.	U14MB301	RENJITH. J	CRRI	Ranjith.
2.	U14MB302	RESHMA. R.L.	CRRI	Reshma.
3.	U14MB303	RICHARD ROZARIO. C	CRRI	Richard Rozario
4.	U14MB304	RUBINA.S	CRRI	Rubina.
5.	U14MB305	SABARI KRISHNAN.N	CRRI	[illegible]
6.	U14MB306	SANDHYA.S	CRRI	Sandhya S
7.	U14MB307	SANTHOSH KUMAR. L	CRRI	Santhosh Kumar.
8.	U14MB308	SARAN. S	CRRI	Saran.
9.	U14MB309	SASIDHARAN. V	CRRI	Sasidharan.
10.	U14MB310	SENTAMIL SELVAN .P	CRRI	Senthamil Selvan.
11.	U14MB311	SHALINI. T. C.	CRRI	Shalini
12.	U14MB312	SHANMUGA RAJA. A	CRRI	Shanmuga Raja A.
13.	U14MB313	SHANMUHA PRIYA. S	CRRI	Shanmuha Priya.
14.	U14MB314	SHAREEFA AKHTAR.S	CRRI	Shareefa Akhtar
15.	U14MB315	SHEMBIYAN. R.M.	CRRI	Shembiyan
16.	U14MB316	SIKKANDAR. A	CRRI	Shikkandar A.
17.	U14MB317	SINDHU. M	CRRI	Sindhu
18.	U14MB318	SIVARAJ. S	CRRI	Sivaraj. S
19.	U14MB319	SOUNDARYA. S	CRRI	Soundarya. S.
20.	U14MB320	SOWMYA DEVI. N	CRRI	Sowmya Devi

RESOURCE PERSON

DR. CHANDRASEKAR

DEPARTMENT OF ANAESTHESIOLOGY SRI LAKSHMI NARAYANA INSTITUTE OF MEDICAL SCIENCES OSUDU, KUDAPAKKAM, PUDUCHERRY-605 502

COORDINATOR

DR. M KALASREE

Annexure III

MCQ: TRAUMA LIFE SUPPORT

1. A------injury occurs when a patient is such by flying shrapnel from a blast

    a. Primary

    b. Secondary

    c. Tertiary

    d. Quaternary

2. What is the most common mechanism of injury from tractor accident

    a. Ejection

    b. Overturn

    c. Burns

    d. Falls

3. Oxygen, cervical collars ,backboards and personal protective equipments are all considered --------for trauma patients

    a. Specialized care

    b. Essential equipments

    c. Universal necessities

    d. Standard precaution

4. Being thrown by a blast wave and impacting the ground in what type of injury

    a. Tertiary

    b. Primary

    c. Quaternary

    d. Secondary

5. Injury to thorax below ------should increase suspicious of abdominal injury as well

a. 3rd ICS

b. 2ND ICS

c. 4TH ICS

d. 1ST ICS

6. What is a major concern for a patient that was involved in a high energy event

a. Checking vitals before airway

b. The increased chance for serious injury

c. Rapid transportation via helicopter

d. Securing the scene from onlookers

7. The procedure used prevent contamination by a patient body fluids is termed

a. Standard precaution

b. Essential equipment

c. OPIM

d. ITLS primary survey

8. Which of the following is not a consideration when assessing for injuries due to a fail

a. Distance of the fall

b. Anatomical area structure

c. Surface structure

d. Correlation forces

9. Which of the following has the largest effect regarding energy transfer into a patient

a. Mass

b. Weight

c. Velocity

d. Height

10. In what direction do the majority of tractor overturn occurs

   a. To the rear

   b. To the side

   c. To the back

   d. To the front

T. C. Shalini

8/10

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Sivaraj .S

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Annexure V

Student Feedback Form

Course Name: **COMPREHENSIVE TRAUMA CARE SUPPORT**
Subject Code: **ANAES 10**

Name of Student: ____ Roll No.: ______________

We are constantly looking to improve our classes and deliver the best training to you. Your evaluations, comments and suggestions will help us to improve our performance

Sl. NO	Particulars	1	2	3	4	5
1	Objective of the course is clear					
2	Course contents met with your expectations					
3	Lecturer sequence was well planned					
4	Lectures were clear and easy to understand					
5	Teaching aids were effective					
6	Instructors encourage interaction and were helpful					
7	The level of the course					
8	Overall rating of the course	1	2	3	4	5

*** Rating: 5 – Outstanding; 4 - Excellent; 3 – Good; 2– Satisfactory; 1 - Not-Satisfactory**

Suggestions if any:

Annexure V

Student Feedback Form

Course Name: **COMPREHENSIVE TRAUMA CARE SUPPORT**
Subject Code: **ANAES 10**

Name of Student: Shalini. T.C Roll No.: U14MB311

We are constantly looking to improve our classes and deliver the best training to you.

Your evaluations, comments and suggestions will help us to improve our performance

Sl. NO	Particulars	1	2	3	4	5
1	Objective of the course is clear				✓	
2	Course contents met with your expectations			✓		
3	Lecturer sequence was well planned			✓		
4	Lectures were clear and easy to understand		✓		✓	
5	Teaching aids were effective		✓			
6	Instructors encourage interaction and were helpful			✓		
7	The level of the course				✓	
8	Overall rating of the course	1	2	3	4	5

*** Rating: 5 – Outstanding; 4 - Excellent; 3 – Good; 2– Satisfactory; 1 - Not-Satisfactory**

Suggestions if any:

Annexure V

Student Feedback Form

Course Name: **COMPREHENSIVE TRAUMA CARE SUPPORT**
Subject Code: **ANAES 10**

Name of Student: Soumya devi Roll No.: U14MB320

We are constantly looking to improve our classes and deliver the best training to you. Your evaluations, comments and suggestions will help us to improve our performance

Sl. NO	Particulars	1	2	3	4	5
1	Objective of the course is clear				✓	
2	Course contents met with your expectations			✓		
3	Lecturer sequence was well planned				✓	
4	Lectures were clear and easy to understand					✓
5	Teaching aids were effective			✓		
6	Instructors encourage interaction and were helpful				✓	
7	The level of the course					✓
8	Overall rating of the course	1	2	3	4	5

*** Rating: 5 – Outstanding; 4 - Excellent; 3 – Good; 2– Satisfactory; 1 - Not-Satisfactory**

Suggestions if any:

Good.

Date: 02.12.2019

From
Dr M Kalasree
Head Of Department Incharge,
Department of Anaesthesia
Sri Lakshmi Narayana Institute of Medical Sciences
Puducherry

To
The Dean,
Sri Lakshmi Narayana Institute of Medical Sciences
Puducherry

Sub: Completion of value-added course: Comprehensive Trauma Care Support

Dear Sir,

With reference to the subject mentioned above, the department has conducted the value-added course titled: Comprehensive Trauma Care Support in July- Dec 2019 for 20 students. We solicit your kind action to send certificates for all the participants, whose name list is attached with this letter. Also, I am attaching the photographs captured during the conduct of the course.

Kind Regards,

Dr. M Kalasree

Sri Lakshmi Narayana Institute of Medical Sciences
Osudu, Kudapakkam, Puducherry - 605 502.

Encl: Certificates

Photographs

Sri Lakshmi Narayana Institute of Medical Sciences

Affiliated to Bharath Institute of Higher Education & Research

(Deemed to be University under section 3 of the UGC Act 1956)

CERTIFICATE OF MERIT

This is to certify that _____RUBINA S______ has actively participated in the Value Added Course on Comprehensive Trauma Life Support held during July - December 2019 Organized by Sri Lakshmi Narayana Institute of Medical Sciences, Pondicherry- 605 502, India.

Dr. CHANDRASEKAR
RESOURCE PERSON

DEPARTMENT OF ANAESTHESIOLOGY
SRI LAKSHMI NARAYANA INSTITUTE
OF MEDICAL SCIENCES
OSUDU, KUDAPAKKAM, PUDUCHERRY-605 502.

Dr. KALASREE M
COORDINATOR

Sri Lakshmi Narayana Institute of Medical Sciences
Osudu, Kudapakkam, Puducherry - 605 502.

Sri Lakshmi Narayana Institute of Medical Sciences

Affiliated to Bharath Institute of Higher Education & Research

(Deemed to be University under section 3 of the UGC Act 1956)

CERTIFICATE OF MERIT

This is to certify that ________SARAN S_______ has actively participated in the Value Added Course on Comprehensive Trauma Life Support held during July - December 2019 Organized by Sri Lakshmi Narayana Institute of Medical Sciences, Pondicherry- 605 502, India.

Dr.CHANDRASEKAR
RESOURCE PERSON

DEPARTMENT OF ANAESTHESIOLOGY
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OSUDU, KUDAPAKKAM, PUDUCHERRY-605 502.

Dr. KALASREE M
COORDINATOR

Sri Lakshmi Narayana Institute of Medical Sciences
Osudu, Kudapakkam, Puducherry - 605 502.


COMPREHENSIVE TRAUMA LIFE SUPPORT
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