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Trauma team

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Editor's key points

- 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.

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.

Keywords: patient care team; patient outcome assessment; resuscitation; task performance and analysis; wounds and injuries

Trauma is the leading cause of death in the age group up to 44 yr in the Western world,[1–3] 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.[7–10]

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.

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

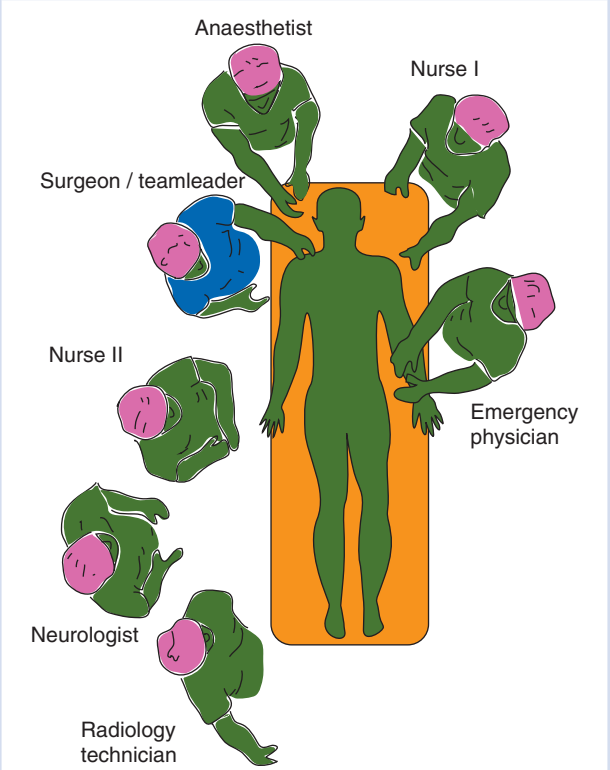

Fig 1 Set-up of the multidisciplinary trauma team in the University Medical Centre Utrecht.

Table 1 Tasks 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

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.[14–16] 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]

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.[21–23] 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.[25–27] 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.[28 29]

Besides leadership, other human factors such as communication, supervision, and seeking help are important. These human factors could influence team structure and collaboration,[30 31] 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]

Table 2 Trauma 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

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.[41 42] ATLS courses are nowadays

very common and widely accepted and have resulted in better outcome as was shown in several studies.[43 44] 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[59] or equivocal.[60] 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.[62 63] 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.[63 65–68] 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.[70 71]

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.[72–74] 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.[75–77] While these factors should not be neglected, we now know that acute traumatic coagulopathy (ATC) is an independent predictor of mortality.[78 79]

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 88] 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.

Authors' contributions

D.T.G.-K. and O.M.: literature search and writing up the first draft of the paper; L.L.: concept and outline of the research, revising manuscript critically for important intellectual content, and final approval of the version to be published.

Declaration of interest

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