CLINICAL PRACTICE GUIDELINE

The Treatment of Patients With Severe and Multiple Traumatic Injuries

Edmund A. M. Neugebauer, Christian Waydhas, Sven Lendemans, Dieter Rixen, Michaela Eikermann, Tim Pohlemann

SUMMARY

Background: The care of severely and multiply injured patients is an interdisciplinary challenge. The only existing German-language guideline up to now has been the S1-guideline issued in 2002 by the German Society for Trauma Surgery (*Deutsche Gesellschaft für Unfallchirurgie,* DGU). In this article, we present a new, comprehensive, evidence and consensus based S3-guideline for the treatment of severely and multiply injured patients in the pre-hospital and early in-hospital phases which has been developed with the aim of structural and procedural quality optimization. Its implementation should lower these patients' mortality and improve their quality of life.

Methods: The guideline was developed by a panel consisting of 18 delegates from 11 specialty societies under the lead of the DGU, with designated coordinators for each of three phases of treatment: the pre-hospital phase, the emergency-room phase, and the emergency surgery phase. The key questions to be answered were determined by vote, and then the relevant literature (in English and German, 1995–2010) was systematically searched and evaluated. Key recommendations with explanatory texts were formulated and agreed upon in a nominal group process (NGP) with five consensus conferences and three further Delphi rounds.

Results: 264 recommendations were issued: 66 for the pre-hospital phase, 102 for the emergency-room phase, and 96 for the emergency surgery phase. The three phases were subcategorized according to organizational and anatomical considerations. Topics of major emphasis were, in the pre-hospital phase, the establishment and implementation of correct priorities for treatment; in the emergency-room phase, the creation of clear structures and processes; and, in the emergency surgery phase, the avoidance of secondary injury (i.e., the principle of damage control).

Conclusion: This guideline can only improve outcomes if it is implemented in routine practice. Aside from the guideline itself, the DGU trauma network (www.dgu-traumanetzwerk.de) has issued a set of directions as an aid to its implementation.

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Accidents are still the most common cause of death in children over the age of 1 and in young adults in Germany (1). According to estimates of the Federal Institute for Occupational Safety and Health (BAuA, *Bundesanstalt für Arbeitsschutz und Arbeitsmedizin*; www.baua.de), more than 8 million people are injured in accidents every year (1, 2). Their medical treatment accounts for just under 5% of the direct costs of illness; they account for around 13% of the days of work lost to sickness every year among employed members of the AOK (*Allgemeine Ortskrankenkasse*, a large general statutory health insurance company), and almost a quarter of the years of working life lost in Germany (3).

The management of severely injured patients is an interdisciplinary task (4). The interdisciplinary S3-guideline presented here is evidence- and consensus-based. Its aim is to contribute to the optimization of structure and process quality, through implementation of its recommendations in hospital and pre-hospital care, and thus to further improve outcome quality in terms of patient mortality and quality of life. The recommendations relate to adult patients and are divided into three phases:

- Pre-hospital care
- Emergency room care
- Emergency surgery.

The guideline is aimed first and foremost at physicians and other medical professionals involved in caring for severely injured patients. It thus is an important basis for interdisciplinary care within the Trauma Network of the German Trauma Society (*TraumaNetzwerk DGU [Deutsche Gesellschaft für Unfallchirurgie]*) (5).

Method

The German Trauma Society, the lead medical society in this undertaking, has devolved central coordination for the guideline to the Institute for Research in Operative Medicine (IFOM, *Institut für Forschung in der Operativen Medizin*). The consensus group was made up of 18 representatives from 11 medical societies (*Box 1*).

Because of the difficult conditions in which emergency medicine is practised, very few studies with a high level of evidence exist on the various phases of the treatment of multiply injured patients. For example, incomplete control for sources of bias, heterogeneity in

the care systems being studied, and the difficult conditions in the emergency situation influenced the collection of data and study design in the evaluated publications. In formulating the recommendations, priority was given to the studies with the highest level of evidence available. The methods of the literature search and the search strategy are described in the guideline report available at http://www.awmf.org/uploads/tx_szleitlinien/012–019m_S3_Polytrauma_Schwerverletzten-Behandlung_2011–07.pdf (in German) (*Figure*, *eBox*).

Formulation of recommendations and consensus formation

The recommendations and recommendation grades were agreed in five consensus conferences. Three grades of recommendation were possible (A = strongly recommended; B = recommended; 0 = no recommendation). The key recommendation was formulated accordingly as: "definitely do it" ("*soll*"), "probably do it" ("*sollte*") or "may do it" ("*kann*"). In determining the grade of recommendation, in addition to the underlying evidence, risk-benefit considerations were also taken into account, as were the directness and homogeneity of the evidence, along with clinical expertise (7). Most of the recommendations were decided by "strong consensus" (>95% of participants agreed). Overall, because of the complexity of illness in this research field, unfortunately very few randomized studies exist (evidence level I). The guideline is valid until December 2014.

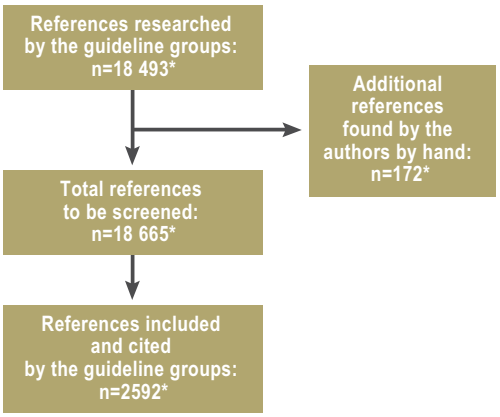
Results

Despite the limitations in the quality of some of the studies, it was possible to make clear recommendations for most key questions for clinical practice (66 for pre-hospital care, 102 for emergency room care, and 96 for emergency surgery) (*Box 2*).

Pre-hospital care

Within the structured emergency services, rapid and smoothly running medical care of a severely injured patient starts at the accident site. The emergency services must work together closely with the trauma centers that will take over the patient's care. To this end, the 2008 Key Points Paper (4) on emergency medical care of patients in hospital and before hospital is reached demanded that for major emergency medical clinical situations such as attending a severely injured patient, definitive clinical treatment should be achieved within 90 minutes. To make this possible, a time from emergency call to hospital admission of 60 minutes must be attained. Caring for a severely injured patient involves a sequence of actions that follow certain priorities. In the pre-hospital phase, very few invasive interventional possibilities are available; of these, the most important steps (airway management, securing oxygenation, volume replacement, placement of a chest drain, positioning of the patient) are presented in the guideline in terms of indications and implementation.

FIGURE



Flow diagram of the literature search.

*Because of the large number of different guideline sections and author groups, the research periods vary and there may be overlaps in the references. The inclusion/exclusion criteria vary from section to section, and this was taken account of in the recommendation grades as appropriate.

Emergency anesthesia, airway management, and ventilation of severely and multiply injured patients

In the sequence of prioritized care, securing the airways (level A problem) and respiration (level B problem) come first. Endotracheal intubation and ventilation, and hence securing of the airways, with the aim of the best possible oxygenation and ventilation of the patient, is a central therapeutic measure. The key recommendations are based strictly on objectively measurable findings of impaired vital functions. Thus, in multiply injured patients with apnea or gasping (<6 breaths per minute) in the pre-hospital phase, emergency anesthesia, endotracheal intubation, and ventilation should be carried out (grade of recommendation: A).

Other pre-hospital indications for intubation (grade of recommendation: B) are:

- Hypoxia (SpO_2 <90%) despite administration of oxygen and after tension pneumothorax has been ruled out
- Severe head injury (Glasgow Coma Scale [GCS] <9)
- Trauma-associated hemodynamic instability (RR_{sys} <90 mm Hg), and
- Severe chest injury with respiratory insufficiency (>29 breaths per minute).

When deciding for or against intubation, the first things to take into account are experience and routine practice, but the following may also be relevant: conditions at the accident site (e.g., patient is trapped, rescue time), type of transport, transportation time, concomitant injuries around the airway, and anything that might

BOX 1

Guideline group

Professional societies participating in the consensus process: delegates with right to vote and designated coordinators of the three phases of treatment

- **German Trauma Society (*Deutsche Gesellschaft für Unfallchirurgie* [lead organization])**
  represented by
  – Prof. Tim Pohlemann (President)
  – Prof. Hartmut Siebert (General Secretary)
  – Prof. Andreas Seekamp
  – Prof. Klaus Michael Stürmer
  Treatment phase coordinators:
  – Prof. Christian Waydhas
  – Dr. Sven Lendemans
  – Prof. Steffen Ruchholtz
  – Prof. Bertil Bouillon
  – Prof. Dieter Rixen
- **German Society of Anaesthesiology and Intensive Care Medicine (*Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin*)**
  – Prof. Bernd W. Böttiger
  – Prof. Jürgen Schüttler
- **German Society of Vascular Surgery (*Deutsche Gesellschaft für Gefäßchirurgie*)**
  – PD Thomas Bürger
- **German Society for Craniomaxillofacial Surgery (*Deutsche Gesellschaft für Mund-, Kiefer- und Gesichtschirurgie*)**
  – Prof. Ralf Gutwald
- **German Urology Society (*Deutsche Gesellschaft für Urologie*)**
  – Prof. Markus Hohenfellner
- **German Society for General and Visceral Surgery (*Deutsche Gesellschaft für Allgemein- und Viszeralchirurgie*)**
  – Prof. Ernst Klar
- **German Society for Neurosurgery (*Deutsche Gesellschaft für Neurochirurgie*)**
  – Prof. Eckhard Rickels
- **German Society for Thoracic Surgery (*Deutsche Gesellschaft für Thoraxchirurgie*)**
  – Prof. Lothar Swoboda
- **German Roentgen Society (*Deutsche Röntgengesellschaft*)**
  – Univ.-Prof. Thomas J. Vogl
- **German Ear, Nose and Throat Society (*Deutsche Gesellschaft für HNO-Heilkunde, Kopf- und Halschirurgie*)**
  – Dr. Frank Waldfahrer
- **German Society for Surgery of the Hand (*Deutsche Gesellschaft für Handchirurgie*)**
  – Prof. Margot Wüstner-Hofmann

impede intubation. This is why the guideline requires, with a grade A recommendation, that emergency personnel be regularly trained in emergency anesthesia, endotracheal intubation, and alternative ways of securing an airway (mask ventilation, supraglottic airway devices, emergency cricothyroidotomy). Intubation without the actual presence of life-threatening impairments of vital functions (defensiveness, aggression, or danger to self or others) may do more harm than good.

Volume replacement

In severely injured patients, volume replacement should be started in such a way that it can be carried out in reduced form if uncontrollable bleeding occurs, in order to keep the circulation at a stable low level and not exacerbate the bleeding (grade of recommendation: B). In hypotensive patients with head injury, volume replacement should be carried out with the aim of restoring normal blood pressure (grade of recommendation: B). Normotensive patients do not require volume replacement, but venous access should be placed (grade of recommendation: B). Volume replacement in trauma patients should use crystalloids (grade of recommendation: B). Isotonic saline solution should not be used; Ringer's malate, or alternatively Ringer's acetate or Ringer's lactate, should be preferred (grade of recommendation: B).

Chest injury

The decision whether to carry out drainage or decompression of the pleural cavity or not is based on examination, assessment of findings, and weighing up of risks and benefits where diagnostic possibilities are limited.

A clinical examination (at least including respiration rate and auscultation of the lungs, chest, and respiratory function) should be carried out. A suspected diagnosis of pneumothorax and/or hemothorax should be made if breathing sounds are weaker or absent on one side (so long as the tube has been correctly placed). Absence of such auscultation findings largely rules out pneumothorax of any major degree, especially if the patient is normopneic and has no chest pain (grade of recommendation: A).

A suspected diagnosis of tension pneumothorax should be made if auscultation reveals no breathing sounds on one side (so long as the tube is correctly placed) and, in addition, typical symptoms are present, especially severe respiratory impairment or an upper inflow congestion in combination with arterial hypotension (grade of recommendation: B). A clinically suspected tension pneumothorax should be decompressed immediately (grade of recommendation: A). Pneumothorax diagnosed on the basis of auscultation findings in a patient on positive pressure ventilation should be decompressed (grade of recommendation: B). Pneumothorax diagnosed on the basis of auscultation findings in patients not on ventilation should usually be managed by close clinical observation (grade of recommendation: B).

For recommendations relating to the initial treatment of patients with injuries to the head, spine, extremities, and pelvis, please refer to the guideline.

General recommendations

In addition to treating the patient, there are other important elements in the pre-hospital management such as choosing the destination hospital. Apart from hospital structure, this decision may be influenced by organizational and logistical circumstances as well as medical ones. Inextricably linked to this is the question of whether the patient is in fact severely injured (risk of overtriage). The aim should be to deliver every patient in whom severe injury is either suspected for good reason or proven, immediately and directly to a certified trauma center in the DGU Trauma Network.

Overall, aspects, interventions, and guidelines must be embedded in a general pathway of action that sets priorities and prescribes paths of action. A framework of this kind can be provided by programs such as Prehospital Trauma Life Support (PHTLS) for the pre-hospital phase and Advanced Trauma Life Support (ATLS) and the European Trauma Course (ETC) for the hospital phase.

Emergency room care

Recommendations on structure in the emergency room

Managing a severely injured patient in the emergency room makes great demands on the management process, because of acute events and the large number of treating physicians from different specialties. The basis of reproducible and valid management is well-tuned collaboration between the different medical disciplines and the running of processes in parallel. It is important for every hospital to have an interprofessional emergency room algorithm that coordinates between the specialties involved, and for all involved personnel to know it and practice it regularly.

The introduction of regionalized trauma centers with defined standards in the management of trauma patients resulted in a reduction in the rate of avoidable deaths in the USA (21, 22). To further improve the management of multiply injured patients in Germany as well, and make it more uniform throughout the country, it would be sensible to define the requirements in terms of structure and personnel, and to standardize them as far as possible.

In consensus with all medical societies, it is recommended that:

- The care of multiply injured patients should be undertaken by fixed teams (emergency room teams) who work according to pre-structured plans and/or have undergone special training (grade of recommendation: A).
- The basic emergency room team should consist of at least three doctors (two surgeons, one anesthetist); at least one anesthetist and one surgeon should be at the consultant level (grade of recommendation: A).
- Trauma centers should maintain extended emergency room teams (grade of recommendation: A).
- Other senior doctors needed for continued treatment of the patient should arrive within 20 to 30 minutes of being called (grade of recommendation: A).
- The emergency room should be 25 to 50 m^2 in size (per patient to be treated) (grade of recommendation: B).
- The emergency room, ambulance entrance, radiology department, and surgical department should be in the same building. The helicopter landing pad should be within the hospital grounds (grade of recommendation: B).

The trauma/emergency room team should be activated for the following injuries/situations (grade of recommendation: A):

- Systolic blood pressure <90 mm Hg after trauma
- Penetrating injuries to the neck and torso
- Gunshot wounds to the neck and torso
- Glasgow Coma Scale (GCS) <9 after trauma
- Respiratory impairment/requirement for intubation after trauma
- Fracture of more than two proximal bones
- Unstable chest/pelvic fractures
- Amputation injury proximal to hands/feet
- Spinal cord injury
- Open head wound/burns 20% and grade ≥2b.

The trauma/emergency room team should be activated for the following additional criteria (grade of recommendation: B):

- After a fall from more than 3 m height
- After a road traffic accident (RTA) with frontal impact with intrusion by more than 50 to 75 cm, a change in speed of delta >30 km/h, collision involving a pedestrian or two-wheeler, death of a driver or passenger, and/or ejection of a driver or passenger.

Because identifying and treating severe injury is part of the core competence in trauma surgery in the orthopedics and trauma surgery specialism, it may be legitimate for physicians qualified in this discipline to lead treatment in the emergency room (9). However, other workable strategies do exist (10–12). The guideline makes allowances in this sensitive area at various points, since even strategies that foresee purely multidisciplinary teamwork without a team leader can work. However, in such cases it must be clearly laid down who takes responsibility for what situations in the emergency room, if only to be prepared for any medicolegal challenges (13). This does not release the trauma surgeon from the responsibility for guiding the whole process of management of the severely injured patient right up to his or her rehabilitation.

Emergency surgery phase

According to data held in the DGU trauma registry, more than 65% of all severely injured patients have injuries to the extremities and/or pelvic injuries (Abbreviated Injury Scale, AIS). Despite this, there are contradictory surgical management strategies for femoral fractures in patients with multiple injuries (14).

BOX 2

Division of the guideline into three treatment phases and anatomic and organizational sections

- **Pre-hospital care**
  - Introduction
  - Airway management, ventilation, and emergency anesthesia
  - Volume replacement
  - Chest
  - Head injury
  - Spine
  - Extremities
  - Urogenital tract
  - Transport and destination hospital
  - Mass casualty incidents (MCI)

- **Emergency room care**
  - Introduction
  - Personnel and equipment requirements
  - Criteria for activation of the emergency room
  - Chest
  - Abdomen
  - Head injury
  - Pelvis
  - Urogenital tract
  - Spine
  - Extremities
  - Hand
  - Foot
  - Maxilla and midface
  - Neck
  - Resuscitation
  - Coagulation system
  - Interventional hemostasis

- **Emergency surgery**
  - Introduction
  - Chest
  - Diaphragm
  - Abdomen
  - Head injury
  - Urogenital tract
  - Spine
  - Upper extremity
  - Hand
  - Lower extremity
  - Foot
  - Maxilla and midface
  - Neck

According to analyses of the DGU trauma registry, in some hospitals in Germany femoral fractures in multiply injured patients are primarily treated with an external fixator, in others with a medullary nail, while in many they are treated sometimes with one, sometimes with the other, in every ratio you can think of (14).

The aim of this section of the guideline was to gain an overview of the evidence underlying different management strategies in the first (emergency) surgical phase after multiple injury, and from this either to derive clinical treatment algorithms or to document the need for scientific verification of the evidence.

In terms of fracture management, we first assumed a closed fracture without vascular involvement and with no compartment syndrome. These are regarded as indications for emergency surgery and require a different management strategy. In many complex patterns of injury, it has to be taken into account that definitive primary treatment can only be considered if:

- careful planning has been carried out (if appropriate, on the basis of 3D computed tomography);
- the expected duration of surgery is not too long;
- an experienced surgeon is present;
- the right implant is already in the hospital.

In formulating the guideline, it was assumed that the patient was otherwise hemodynamically stable with additional injuries of the extremities. The management strategy with a patient with multiple injuries and cardiopulmonary, metabolic, or coagulatory "instability" may be very different from this. In terms of risk assessment of a multiply injured patient as an aid to management decision making, please refer to the relevant literature (14–20). Damage control is a strategy for management of multiply injured patients that aims to minimize secondary damage and maximize the outcome for the patient. In the area of fracture treatment, for example, this would mean not carrying out primary definitive osteosynthesis, but instead stabilizing the fracture temporarily with an external fixator. In a randomized controlled trial (RCT) it was shown that this significantly reduces postoperative inflammatory reaction in the form of IL-6 release (odds ratio [OR] = 0.21; 95% confidence interval: 0.133 to 0.32; $p<0.0001$) (17). The intention is to keep the additional trauma burden, in terms of secondary injury, as low as possible by carrying out a less invasive operation with a shorter operative time. For this reason,

- the patient's individual biological characeristics (e.g., age),
- the overall severity of the injuries,
- serious additional injuries (e.g. a severe head injury),
- the operative time required,
- compensating disturbances of vital signs (borderline patients), and
- the patient's physiological condition (e.g., metabolism, coagulation, temperature)

all have to be included in the decision making process.

Implementation in patient management

The success of the guideline depends on its implementation in clinical practice. The DGU Trauma Network (www.dgu-traumanetzwerk.de) has already formulated specifications for this, which will undoubtedly make implementation easier. These provide among other things for:

- the introduction of a standardized set-up in terms of personnel, structure, and organization (e.g., emergency room equipment),
- the formulation of standardized treatment procedures and movement criteria for the early phase of care of multiply injured patients on the basis of the S3 guideline, and
- participation in internal and external quality assurance measures, and recording current case numbers and procedures on the basis of the Trauma Registry and the specifications of the Trauma Network to promote quality and safety of treatment (www.traumaregister.de, www.dgu-traumanetzwerk.de) and other programs.

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eBox

Method

The guideline project was first announced in December 2004, with another announcement in May 2009. The German Trauma Society (DGU, *Deutsche Gesellschaft für Unfallchirurgie*) as the lead agency transferred the role of central coordinator for these guidelines to the Institute for Research in Operative Medicine (IFOM, *Institut für Forschung in der Operativen Medizin*). The S3-Guideline Consensus Group consisted of 18 representatives from 11 medical societies (*Box 1*). A coordinator was appointed for each of the three treatment phases. Because of the difficult conditions in which emergency medicine is practiced, very few studies with a high level of evidence exist on the various phases of the treatment of multiply injured patients. For example, incomplete control for sources of bias, heterogeneity in the care systems being studied, and the difficult conditions in the emergency situation influenced the collection of data and study design in the evaluated publications. The selection and evaluation of the literature included in the guideline was carried out by the authors of each individual section according to the criteria of evidence-based medicine. The evidence classifications of the Oxford Centre of Evidence-Based Medicine (CEBM), March 2009 version, were used as the basis for the presentation of evidence (6). In formulating the recommendations, priority was given to the studies with the highest level of evidence available. After the key questions had been formulated for the systematic literature search and evaluation, the Medline database was searched (via PubMed) using Medical Subject Headings (MeSH), with some additional use of free text searches. Additional searches were carried out of the Cochrane Library (Central). The publication period was defined as 1995 to 2010 and the publication languages were English and German. The literature search method and the search strategy are described in the guideline report under http://www.awmf.org/uploads/tx_szleitlinien/012–019m_S3_Polytrauma_Schwerverletzten-Behandlung_2011–07.pdf (in German) (*Figure*). The participating medical societies each nominated (at least) one delegate, who worked as the representative of that society in the development of the guideline. Each medical society had a vote in the consensus process.