# Comparison of the Prehospital Trauma Life Support recommendations and the German national guideline on treatment of patients with severe and multiple injuries

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**BACKGROUND:** The Prehospital Trauma Life Support (PHTLS) concept is well established throughout the world. The aim is to improve prehospital care for patients with major trauma. In 2011, a German Level 3 (S3) evidence- and consensus-based guideline on the treatment of patients with severe and multiple injuries was published. The scope of this study was the systematic comparison between the educational content of the worldwide PHTLS concept and the German S3 Guideline.

**METHODS:** A total of 62 key recommendations of the German S3 Guideline were compared with the content of the English PHTLS manual (eighth edition). Depending on the level of agreement, the recommendations were categorized as (1) agreement, (2) minor variation, or (3) major variation. Comparison was done via a rating system by a number of international experts in the field of out-of-hospital trauma care. The Delphi method was used to get the final statements by indistinct or board-ranged ratings.

**RESULTS:** Overall, there was no conformity in 12%. In 68% a total agreement and in 88% conformity with slight differences of minor variations were found between the key recommendations of the guideline and the PHTLS manual. The PHTLS primary assessment has a large conformity for the following individual priorities: airway, 92%; breathing, 92%; circulation, 63%; disability, 100%; exposure, 89%.

**CONCLUSIONS:** According to our comparison, the PHTLS manual is largely compatible with the German S3 Guideline from 2011. The 12% divergent statements concern mainly fluid resuscitation. Minor deviations in the prehospital care are due to a national guideline with an emergency medical service with emergency physicians (S3 Guideline) and a global PHTLS concept. (*J Trauma Acute Care Surg.* 2016;81: 388–393.

**KEY WORDS:** EMS; evidence-based medicine; injury; out-of-hospital treatment; trauma patients.

In the 1980s, Advanced Trauma Life Support (ATLS)[1] was developed as a concept to treat patients in the trauma bay. Prehospital Trauma Life Support (PHTLS)[2] followed some years later as a prehospital concept, modeled after the successful ATLS program. Both courses have successfully promulgated worldwide and are standards in interdisciplinary acute trauma care today.

The ABCDE algorithm (airway and C-spine protection, breathing, circulation, disability, exposure) is not only an established scheme of different courses and medical trainings, but also the core component of PHTLS and ATLS.

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In July 2011, a Level 3 (S3) evidence and consensus-based guideline on the treatment of multiply injured trauma patients was published in Germany.[3] This guideline refers to clinical symptoms, corresponding measurements and treatments, and a care strategy, which is based on scientifically reliable data from which appropriate recommendations can be pronounced.[3] The guideline was divided into an out-of-hospital and in-hospital section.

In Germany, PHTLS was introduced in 2007 by the German Association of Paramedics (DBRD), supported by the German Trauma Society (Deutsche Gesellschaft für Unfallchirurgie [DGU]), German Society of Anesthesiology and Intensive Care Medicine, and Professional Association of German Anesthetists. Especially in the early stage, there were a lot of reservations and doubts. The most common objection was that the German double response emergency medicine services (EMS) system staffed with out-of-hospital physicians and paramedics differed too much from the American paramedic system and that the discrepancies of infrastructure in the prehospital healthcare were too large. Nevertheless, PHTLS has become over the last years a generally accepted training program for all providers (paramedics and out-of-hospital physicians) in the EMS system around Europe.

The German S3 Guideline is considered the professional basis for trauma care in Germany and is recognized as the criterion standard by all participants in the EMS. Therefore, the conformity of PHTLS with the German S3 Guideline is very important for the further acceptance of PHTLS in Germany.

Our hypothesis is that the course content of PHTLS coincides largely with the German S3 Guideline. The aim of this study is a systematic comparison between the German S3 Guideline key recommendations and the PHTLS principles.

## METHODS

### German S3 Guideline on Treatment of Patients With Severe and Multiple Injuries

The German S3 Guideline on Treatment of Patients With Severe and Multiple Injuries[3] was developed under the direction of the German Trauma Society (DGU). The S3 Guideline is a highly evidence-based and also consensus-based tool. It is based on the current state of scientific knowledge and on procedures proven in practice.

The representatives of the participating societies drafted a total of 264 key recommendations, as recommended for a Level 3 guideline formation. The guideline cites the prehospital, the trauma bay, and the initial surgical phase. This S3 Guideline includes formal consensus finding, systematic literature search, evaluation and classification of studies, and recommendation according to the criteria of evidence-based medicine, clinical algorithms, outcome analysis, and decision. This strategy follows in all aspects a systematic development. Based on the evidence classification of the Oxford Center of Evidence-Based Medicine,[4] the authors of the chapters selected and evaluated the literature. Three grades of recommendation (GoR) were used. The key recommendations are divided in "shall" (A), "should" (B), or "can" (0) as appropriate. To determine the GoR, further to the evidence, the clinical expertise of the experts[3] was considered. In addition to the core statements, the guideline contains important explanations on the recommendations and their estimation.

### Prehospital Trauma Life Support: The Eighth Edition

Prehospital Trauma Life Support is the recognized standard for prehospital trauma care in 66 countries throughout the world. Prehospital Trauma Life Support combines professional consensus and didactic concept in order to enable efficient training to the course participants.

Prehospital Trauma Life Support represents the prehospital variant of the ATLS concept developed by the American College of Surgeons.[1] Based on the ATLS foundation, the PHTLS concept was developed by the National Association of Emergency Medical Technicians PHTLS Committee and endorsed by the Committee on Trauma of the American College of Surgeons. The PHTLS textbook is based on the ATLS manual[5] but is a separate textbook written by experts in prehospital trauma care and based on current prehospital literature and practices.[2]

### Comparison Between the S3 Guideline and the PHTLS Manual

The 62 key recommendations of the chapter "prehospital" of the S3 Guideline were compared to the teachings of the PHTLS textbook (eighth edition). The corresponding distribution of GoR is shown in Table 1.

**TABLE 1.** Modified Classification From Münzberg et al.[6]

| | |
|---|---|
| Agreement | The key recommendations of the S3 Guideline and the PHTLS manual are identical |
| Minor variation | Slight differences or lack of limit values between S3 Guideline and PHTLS manual |
| Major variation | Marked differences between S3 Guideline and PHTLS manual—clear contradiction |
| No statement | The PHTLS manual contains no statement on a key recommendation made in the S3 Guideline |

For each recommendation of the S3 Guideline, two authors (D.H., M.M.) searched a matching statement in the PHTLS manual. The comparisons between the key recommendations S3 and the PHTLS manual were performed by 12 international experts in the field of emergency and trauma medicine, anesthesiology, surgery, evidence-based medicine, and didactics. They evaluated the findings individually with the use of an Internet-based scoring system and pointed out the variations.

The classification we used for the statements had already been used in the comparison with ATLS by Münzberg et al.[6] Statements were taken as "in agreement," if the teachings of PHTLS agreed with the S3 key recommendations. Conversely, if slight differences or inaccurate statements were recognized, the statement was recorded as a minor variation. All the other statements showing significant differences were classified as "major variation." Key recommendations that were not considered in the PHTLS manual were marked but were ultimately not assessed (no-statement group).

We regarded the variation groups as ordinal scaled variables and calculated the conformity of the experts with the median (3 = in agreement, 2 = minor variation, 1 = major variation, 0 = no statement). If the range of the evaluation of the experts included more than two classifications per statement or if the rating result was very narrow, we determined that these statements needed to be re-evaluated by the experts in a Delphi method. Based on this result, the authors defined the final statement.

### Statistical Analysis

The concordance of the expert assessment was calculated with SPSS statistical software, version 23 (IBM Corp, Armonk, NY) by Fleiss κ for multiple raters. Classification according to McHugh[7] was defined as follows: 0 or less as no agreement, 0.01 to 0.20 as none to slight, 0.21 to 0.40 as fair, 0.41 to 0.60 as moderate, 0.61 to 0.80 as substantial, and 0.81 to 1.0 as perfect agreement; $p < 0.05$ was considered to be statistically significant.

## RESULTS

In the first round of the expert rating, we had n = 36 (58%) "agreement," n = 18 (29%) "minor variation," and n = 5 (8%) "major variation." For three statements of the German S3 Guideline, no correlating PHTLS statements were found. Fleiss κ was 0.236 (fair) ($p < 0.001$; 95% confidence interval, 0.215–0.715).

Six statements were discussed in the Delphi method as the raters were more than two categories apart. One statement was discussed because the 12 raters voted 6:6 for two different

categories. Re-evaluation using the Delphi method upgraded five statements from the minor-variation group to the agreement group, one statement from the minor-variation group was corrected into the major-variation group, and one recommendation from the no-statement group was adjusted into the major-variation group.

According to the Delphi method, the final results were n = 42 (70%) "agreement," n = 11 (18%) "minor variation," and n = 7 (12%) "major variation," based on 60 comparable statements (Fig. 1). Two statements of the German S3 Guideline were without a corresponding PHTLS statement.

Regarding the GoR, GoR A has the highest correlation with "agreement" (n = 21), followed by GoR B with "agreement" (n = 18) (Table 2).

Table 3 shows the distribution of agreements in ABCDE primary assessment categories. The closest match is given in "disability" with 92% (n = 11), whereas the section "circulation" has the most variations with 31% (n = 5).

## DISCUSSION

The result of the present study shows a considerable agreement between the teachings of PHTLS and the recommendations of the S3 Guideline on Treatment of Patients With Severe and Multiple Injuries, and therefore a good applicability in the German EMS is given. Overall, 88% of recommendations in the German S3 Guidelines and PHTLS are in agreement or have only minor variations. The 12% divergent statements concern mainly fluid resuscitation and reflect the different German S3 and worldwide PHTLS treatment approaches.[3] The proof of reliability with low Cohen κ confirmed the chosen methodological approach to discuss the first results of the comparison in a Delphi process and set the final score.

The comparison of the two guidelines showed that some recommendations, although aiming at the same treatment, are far more detailed in the one or in the other guideline, which

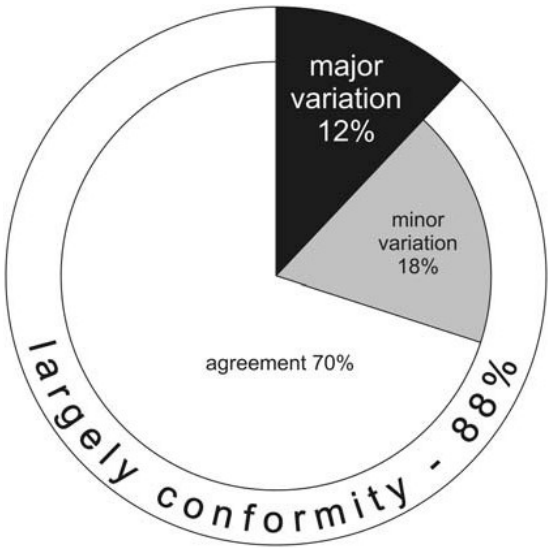


**Figure 1.** The PHTLS manual is in 88% compatible with the German S3 Guideline 2011. The 12% divergent statements concern mainly fluid resuscitation.

**TABLE 2.** Comparison Between the Grade of Recommendations GoR and the Ratings

| | Agreement | Minor Variation | Major Variation | No Statement |
|---|---|---|---|---|
| GoR A | 21 | 3 | 0 | 1 |
| GoR B | 18 | 7 | 6 | 1 |
| GoR 0 | 3 | 1 | 1 | 0 |
| Total | 42 | 11 | 7 | 2 |

often resulted in "minor variation" in our study. One example is the comparison of the S3 Guideline and PHTLS key recommendation on blood pressure in patients with traumatic brain injury. While the S3 Guideline recommends, without detailed values, maintenance of normotension for traumatic brain injuries (GoR B), the PHTLS guideline clearly mentions preserving a systolic value greater than 90 mm Hg. Even though both guidelines have nearly the same substantive focus, the S3 Guideline leaves more space for individual therapy requirements; for example, what can be interpreted in an (elderly) per se hypertensive patient in the concept of "normotension"?

The intubation indications (GoR B) between the PHTLS manual and S3 Guideline differ in some details. Here, the S3 Guideline is more specific than the PHTLS recommendations regarding the indication for invasive airway management (e.g., intubation of the trachea) with the following recommendations: hypoxia ($Spo_2$ <90%) after supplement of oxygen while exclusion of tension pneumothorax, severe traumatic brain injury (Glasgow Coma Scale score <9), and severe chest injury with respiratory insufficiency breathing (rate >29 breaths/min).[8] Prehospital Trauma Life Support is less specific in its indications for intubation, stating "patient who is unable to protect his/her airway, significant oxygenation problem, requiring administration of high concentrations of oxygen, or patient with significant ventilator impairment requiring assisted ventilation."

The importance of education and continuous training of skills in airway management is pointed out by the PHTLS and the S3 Guideline with GoR A. Sufficient experience and training for out-of-hospital physicians or paramedics cannot be maintained by just participating in EMS, emergency operations, and emergency duties.[9–12] Findings from current studies on the learning curve for endotracheal intubation,[12] alternative methods to secure the airway (e.g., laryngeal tube, laryngeal mask),[10,11] and first-pass intubation success[12] underline the need for continuous retraining.

The use of etomidate as a sedative agent in emergency medicine has been a controversial issue for years.[13] It is not

**TABLE 3.** Comparison Between the PHTLS Primary Assessment and the Ratings

| | Agreement | Minor Variation | Major Variation | No Statement |
|---|---|---|---|---|
| Airway | 9 | 3 | 1 | 0 |
| Breathing | 9 | 2 | 0 | 1 |
| Circulation | 9 | 1 | 5 | 1 |
| Disability | 11 | 1 | 0 | 0 |
| Exposure | 4 | 4 | 1 | 0 |
| Total | 42 | 11 | 7 | 2 |

**TABLE 4.** Description of the Main Differences Between S3 Guideline and the PHTLS Eighth Edition Manual

| Subject | German S3 Guideline | PHTLS (Eighth Edition) | GoR | Difference |
|---|---|---|---|---|
| Etomidate | Etomidate should be avoided as an induction agent because of the associated adverse effects on adrenal function (ketamine is usually a good alternative here) | Etomidate is mentioned in the table "Common Drugs Used for Pharmacologically Assisted Intubation" without regard to adverse effects on adrenal function. Ketamine has also been recommended | GoR B | Opposing recommendation |
| Fluid resuscitation | Isotonic saline solution should not be used; preference should be given to Ringer's malate, or alternatively Ringer's acetate or lactated Ringer's solution | As blood is usually not available in the prehospital setting, lactated Ringer's or normal saline is used for trauma resuscitation. The best crystalloid solution for treating hemorrhagic shock is lactated Ringer's solution | GoR B | Different recommendations |
| Fluid resuscitation | If colloidal solutions are used in hypotensive trauma patients, preference should be given to hydroxyethyl starch 130/0.4 | Virtually no research exists involving the use of these synthetic colloid solutions in the civilian prehospital setting, and no data exist on their use in the hospital that shows them to be superior to crystalloid solutions. These products are not recommended for the prehospital management of shock | GoR B | Different recommendations |
| Fluid resuscitation | Hypertonic solutions can be used in multiply injured patients with hypotensive circulation after blunt trauma | An analysis of several studies of hypertonic saline failed, however, to demonstrate improved survival rates over the use of isotonic crystalloids. This solution is not FDA approved for patient care in the United States | GoR 0 | Different recommendations |
| Fluid resuscitation | Hypertonic solutions should be used in penetrating trauma if prehospital volume replacement is carried out | An analysis of several studies of hypertonic saline failed, however, to demonstrate improved survival rates over the use of isotonic crystalloids. This solution is not FDA approved for patient care in the United States | GoR B | Different recommendations |
| Fluid resuscitation | A hypertonic solution can be used in hypotensive patients with severe traumatic brain injury | A randomized trial of patients with severe traumatic brain injury showed that those who received prehospital resuscitation with hypertonic saline had almost identical neurologic functioning 6 mo after injury compared with those treated with crystalloid. Because of its increased cost and lack of benefit compared with normal saline or lactated Ringer's solution, hypertonic saline is not recommended for routine prehospital volume replacement | GoR 0 | Different recommendations |
| Bladder catheterization | In case of a suspected urethral injury, prehospital bladder catheterization should not be carried out | Even though insertion of a urinary catheter is not usually required in rapid transport circumstances, monitoring urine output is an important tool that can help guide decisions regarding the need for additional fluid therapy during prolonged transport. Insertion of a urinary catheter, if local protocols permit, should be considered so that urine output can be monitored | GoR B | Different recommendations |

particularly surprising that guidelines designed by two different institutions assess the underlying study data and evidence diametrically different and therefore lead in this comparison to a major variation (Table 4). While PHTLS recommends the use of etomidate in patients with trauma, the S3 Guideline comes to the conclusion that etomidate should be avoided because it might cause a reversible adrenal insufficiency (GoR B). Ketamine is recognized as an alternative agent by both groups. A recent review summarizes once more the available evidence:[14] based on the current study situation and the uncertain assessable pharmacological literature for etomidate regarding to the long-term effect of a single application as part

of the induction of anesthesia on mortality, duration of ventilation, time spent, and infection rates, etomidate should be limited to the application in randomized controlled trials. Recent studies have evaluated ketamine as an alternative to etomidate with comparable good effect on the hemodynamic profile and the adjustability of the vocal cord during endotracheal intubation procedures.[15]

Both PHTLS and the S3 Guideline regard the needle decompression of tension pneumothorax as an important measure (GoR A). The S3 Guideline recommends a thoracostomy with or without a chest drain after every decompression, whereas PHTLS is critical toward the thoracostomy as it requires time and a certain training level and carries a risk of complication and infection.

By contrast, the treatment of pneumothorax results in a minor variation. The S3 Guideline recommends that pneumothorax should be treated with a chest tube (GoR B), while, interestingly, since the eighth edition of PHTLS, the chest drain is prehospital optioned for specialized personnel (e.g., air rescue) in pneumothorax.

The potential reason for this "minor variation" is the various prehospital systems (paramedic vs. out-of-hospital physicians) with the corresponding limitations for invasive measures. We should not forget that in the German EMS system the application of a chest tube is a very rare procedure[16] and therefore should be applied only by those out-of-hospital physicians who have obtained the appropriate competence.

In the Resuscitation Guidelines 2015 of the European Resuscitation Council, the needle decompression is equally fast, but suggested as a "success-limited" method.[17] In line with the literature, the needle length is stated as a main problem.[18] It was only possible to demonstrate a success rate of 66% to 81% of decompression with a needle length of only 5 cm. They recommended, as well as PHTLS, a needle length of 8 cm.[18] Currently, these long needles for adequate decompression are often missing in the EMS equipment.

The topic of fluid resuscitation generally results in the most divergent recommendations of the S3 Guideline and PHTLS in the presented comparison.

The S3 Guideline recommends Ringer's malate, or alternatively Ringer's acetate or lactated Ringer's solution (GoR B). Lactated Ringer's solution is also recommended by PHTLS, but PHTLS still mentions the normal saline, which has led to the rating "major variation," as, according to the S3 Guideline, isotonic saline solution should not be used. Lactated Ringer's solution remains the resuscitation crystalloid of choice in the United States today, although it is recommended to minimize the amount of crystalloid administered. Even the use of lactated Ringer's solution needs to be put into question, since superior alternatives such as Ringer's malate and Ringer's acetate are approved here.[19]

Concerning the use of colloidal solutions in hypotensive trauma patients, the S3 Guideline prefers hydroxyethyl starch 130/0.4, whereas PHTLS tends to recommend against colloid solutions, which results in a "major variation." Both statements address closely related issues; however, the statements do not fit in the way that they could directly be compared for congruence.

Europeans prefer colloids because we believe they have more pronounced effects on acute restoration of blood pressure than crystalloids. From the viewpoint of evidence-based medicine, so far neither the conclusion "recommended" nor "not recommended" is justified. This noninferiority of colloids on long-term outcome justifies a GoR 0 (may be used) by the German volume replacement guideline.[19]

Statements to the use of hypertonic solutions were also classified as major variation (Table 4). Hypertonic saline can quickly restore blood pressure in patients with multiple traumas; however, improved long-term survival was not demonstrated. This noninferiority on long-term outcome of hypertonic solutions justifies a GoR 0 (may be used) by the German S3 Guideline. Missing approval of the US Food and Drug Administration (FDA) that may be driven by a vast variety of causes aside from effects of the drug itself is irrelevant for patient treatment in Europe.

Prehospital Trauma Life Support did not take relevant data pointing to benefits of hypertonic solutions in penetrating trauma into account, which led to the German GoR B recommendation.[20] Again, missing FDA approval that may be driven by a vast variety of causes aside from effects of the drug itself is irrelevant for patient treatment in Europe.

Hypertonic saline can quickly restore blood pressure in multiple traumas; however, improved long-term survival was not demonstrated by its use in patients with severe traumatic brain injury.[21] This noninferiority on long-term outcome of hypertonic solutions justifies a GoR 0 (may be used) by the German S3 Guideline. In contrast, referring to one study,[21] PHTLS states "not recommended" for hypertonic saline.

Pain management is mentioned in the S3 Guideline just as "transport should be as gentle as possible and free of pain." Analgesia is an important part of emergency treatment[22] and has to be performed as early as possible during the EMS therapy.[23] Over many decades, in Germany, analgesia was carried out by out-of-hospital physicians, which represents a considerable difference to other non–physician-based EMS systems. In recent years, however, analgesia with opioids or ketamine is slowly becoming routine practice by German paramedics.[24,25] Regardless of which group it is applied, analgesia is considered to be one of the main pillars in the German out-of-hospital EMS community. The recommendations in the PHTLS manual compared with the S3 Guideline are only a minor variation, as the analgesia is considered nuanced and not generally recommended. Their focus is on patients with isolated limb injury or spinal fracture, particularly if prolonged transport occurs and therefore should be avoided in patients with ventilation disorder or shock. This may be due to the different executing professionals but allows the adaptation of the analgesia to the local circumstances.

As in the European setting, with a short rescue time of less than 60 minutes, a bladder catheterization is not useful and furthermore not necessary.[26,27] Because of the multiple-injury patterns in this kind of patient, pelvic or intra-abdominal injuries have to be suspected frequently. In this case, a urethral injury cannot be excluded in the out-of-hospital setting. Again, the PHTLS concept is a worldwide concept, and for this reason, a catheterization might be useful in order to monitor the diuresis during a long transport period in other areas of the world.

A limitation of this study is the subjective rating of the experts. Especially the first round of the expert rating has not

shown a strong consensus, because of different apprehension of the experts. Thus, for all differences in the expert rating, a consensus was found in the Delphi method. This finally showed that there are no clinical significant differences in treatments, except for specific infusion therapy and narcotics.

According to our comparison, the PHTLS manual is largely compatible with the German S3 Guideline from 2011, with 88% of recommendations being equal or having only a minor variation. The 12% divergent statements mainly concern fluid resuscitation, which should be the subject of further research. Minor deviations could be explained by different addressees: the S3 Guideline is a national guideline for the German emergency medical service with emergency physicians. Prehospital Trauma Life Support is a concept for various emergency medical service systems all over the world. All in all, there is a high conformity.

## AUTHORSHIP

D.H. and M.M. conceived the study and compared the recommendations. D.H. drafted the methods and the rating system and managed data. D.H., M.B., A.R.H., U.S., and M.M. performed the data analysis. D.H. and M.M. drafted the manuscript. L.S. and B.G. performed textual analysis and supervised the analysis. All authors contributed substantially to its revision.


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## DISCLOSURE

D.H., L.S., A.H., B.G., and M.M. are PHTLS instructors and receive instructor fees. M.B. was involved as an author and as a representative of the German Society of Anesthesiology and Intensive Care Medicine in the development process of the German S3 Guideline on Treatment of Patients With Severe and Multiple Injuries. D.H. was involved as an author and as a representative of the German Association of Paramedics in the development process of the German S3 Guideline on Treatment of Patients With Severe and Multiple Injuries.

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