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ORIGINAL ARTICLE

Surgical management of injuries to the abdomen in patients with multiple and/or severe trauma– a systematic review and clinical practice guideline update

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Abstract

Purpose Our aim was to update evidence-based and consensus-based recommendations for the surgical management of abdominal injuries in patients with multiple and/or severe injuries based on current evidence. This guideline topic is part of the 2022 update of the German Guideline on the Treatment of Patients with Multiple and/or Severe Injuries.

Methods MEDLINE and Embase were systematically searched to May 2021. Further literature reports were obtained from clinical experts. Randomised controlled trials, prospective cohort studies, cross-sectional studies and comparative registry studies were included if they compared interventions for the surgical management of abdominal injuries in patients with multiple and/or severe injuries. We considered patient-relevant clinical outcomes such as mortality, length of stay, and diagnostic test accuracy. Risk of bias was assessed using NICE 2012 checklists. The evidence was synthesised narratively, and expert consensus was used to develop recommendations and determine their strength.

Results Three studies were identified. The topics of these studies were nonoperative management in haemodynamically stable patients with isolated blunt hepatic ($n=1$) or splenic injuries ($n=1$) and selective angioembolisation ($n=1$). None of the recommendations were modified, one new recommendation was developed, and one was deleted based on the updated evidence and expert consensus. All recommendations achieved strong consensus.

Conclusion The following recommendations are made. All but one of the previous guideline recommendations were confirmed. The recommendation to perform diagnostic peritoneal lavage in exceptional cases was completely deleted. An additional recommendation was made and states that the performance of a diagnostic laparoscopy can be considered in haemodynamically stable patients with penetrating trauma when there is therapeutic uncertainty.

Keywords Surgical management · Abdomen · Blunt trauma · Penetrating trauma · Polytrauma guideline

Introduction

The management of abdominal trauma in patients with multiple injuries is a complex task and therefore a critical challenge. Intra-abdominal haemorrhage cannot be managed in the prehospital setting and can be life-threatening. For this reason, the first objective of the management of abdominal trauma in patients with multiple injuries continues to be controlling intra-abdominal bleeding. The second objective of treatment is to manage intra-abdominal contamination caused by hollow viscus perforation.

Everyday clinical practice shows that the management of abdominal trauma in patients who can be haemodynamically stabilised is undergoing changes. For example, conservative approaches are increasingly used in the treatment

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of patients with blunt abdominal trauma. This applies in particular to patients who are haemodynamically stable or who can be haemodynamically stabilised. Clinical guidelines, like the german Polytrauma guidline, recomment for example in "hemodynamically stable patients with isolated blunt liver or spleen injury, that non-operative management should be pursued [1]."

At the same time, successful interventional procedures are consolidating their role as treatment options as a result of growing expertise and improving technology. This concerns, on the one hand, the radiological intervention, for example, through the recommendation of selective angioembolization in hemodynamically stabilizable patients with liver or spleen injuries when CT indicates arterial bleeding. On the other hand, it also applies to stabilizable patients with penetrating abdominal injuries that can be treated using minimally invasive methods (laparoscopy) [1].

Since the spectrum of indications for minimally invasive abdominal procedures continues to widen in clinical practice, the updated guideline reviewed the current literature in order to identify evidence-based data on the role of minimally invasive techniques in polytrauma patients.

In addition, all existing guideline recommendations on treatment strategies for blunt and penetrating abdominal trauma were re-assessed and their validity was evaluated against the current literature.

The modern management of polytrauma patients with abdominal injuries requires weighing the risks and benefits of different treatment options, which include open surgery, interventional procedures, and conservative approaches. The role and validity of minimally invasive procedures, which have been used for appropriate indications in everyday clinical practice for many years, had to be reassessed on the basis of the evidence from the literature. Decision-making in the management of abdominal trauma has become increasingly complex in recent years.

For this reason, it was important to update the german polytrauma guideline with a view to providing safe and state-of-the-art treatment options.

Methods

This guideline topic is part of the 2022 update of the German Guideline on the Treatment of Patients with Multiple and/or Severe Injuries [1]. The guideline update is reported according to the RIGHT tool [2], the systematic review part according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 reporting guideline [3]. The development and updating of recommendations followed the standard methodology set out in the guideline development handbook issued by the German Association of the Scientific Medical Societies (AWMF) [4]. All methods were defined a priori, following the methods report of the previous guideline version from July 2016 [5] with minor modifications, as detailed below. Parts of the Introduction and Discussion sections of this publication are direct translations from the original guideline text [1].

PICO questions and eligibility criteria

Population, intervention, comparison, and outcome (PICO) questions were retained from the previous guideline version. In addition, the participating professional societies involved in guideline development were asked to submit new PICO questions. The overarching PICO question for this topic area was:

> *In adult patients (≥14 years) with known or suspected polytrauma and/or severe injuries, does a specific surgical approach to the management of abdominal injuries improve patient-relevant outcomes compared to any other intervention?*

The full set of predefined PICO questions is listed in Table S1 (Online Resource 1). The study selection criteria in the PICO format are shown in Table 1.

Literature search

An information specialist systematically searched for literature in MEDLINE (Ovid) and Embase (Elsevier). The search strategy described in the 2016 Guideline was used with modifications. It contained index (MeSH/Emtree) and free text terms for the population and intervention. The searches were completed on 19 May 2021. The start date for update searches was 1 June 2014. Table S2 provides details for all searches. Searches were conducted for inhospital care. Clinical experts were asked to submit additional relevant references.

Study selection

Study selection was performed independently by two reviewers in a two-step process using the predefined eligibility criteria: (1) title/abstract screening of all references retrieved from database searches using Rayyan software [7] and (2) full-text screening of all articles deemed potentially relevant by at least one reviewer at the title/abstract level in Endnote (Endnote, Version: 20 [Software], Clarivate, Boston, Massachusetts, USA, https://endnote.com/). Disagre ements were resolved through consensus or by consulting a third reviewer. The reasons for full-text exclusion were recorded (Table S3, Online Resource 1).

Table 1 Predefined selection criteria

Population:	adult patients (≥14 years) with polytrauma and/or severe injuries[a, b]
Intervention/comparison:	surgical management of abdominal injuries
Outcomes:	any patient-relevant outcome such as mortality, diagnostic test accuracy
Study type:	• comparative, prospective studies (randomised controlled trials, cohort studies) • comparative registry[c] data (incl. case-control studies) • cross-sectional studies (only diagnostic studies) • systematic reviews based on the above primary study types
Language:	English or German
Other inclusion criteria:	• full text of study published and accessible • study matches predefined PICO question
Exclusion criteria:	• multiple publications of the same study without additional information

[a] Defined by an Injury Severity Score (ISS) > 15, Glasgow Coma Scale (GCS) < 9, or comparable values on other scales, or, in the prehospital setting, clinical suspicion of polytrauma/severe injury with a need for life-saving interventions

[b] For new PICO questions, indirect evidence from other populations was eligible for inclusion if direct evidence was unavailable

[c] Using the Agency for Healthcare Research and Quality (AHRQ) definition of registries [6]

Table 2 Grading of recommendations

Symbol	Grade of recommendation	Description	Wording (examples)
⇑⇑	A	strong recommendation	"use…", "do not use…"
⇑	B	recommendation	"should use…", "should not use…"
⇔	0	open recommendation	"consider using…", "… can be considered"

Assessment of risk of bias and level of evidence

Two reviewers sequentially assessed the risk of bias of included studies at study level using the relevant checklists from the NICE guidelines manual 2012 [8] and assigned each study an initial level of evidence (LoE) using the Oxford Centre for Evidence-based Medicine Levels of Evidence (2009) [9]. Any disagreements were resolved through consensus or by consulting a third reviewer.

Data extraction and data items

Data were extracted into a standardised data table by one reviewer and checked by another. A predefined data set was collected for each study, consisting of study characteristics (study type, aims, setting), patient selection criteria and baseline characteristics (age, gender, injury scores, other relevant variables), intervention and control group treatments (including important co-interventions, index and reference tests for diagnostic studies), patient flow (number of patients included and analysed), matching/adjusting variables, and data on outcomes for any time point reported.

Outcome measures

Outcomes were extracted as reported in the study publications. For prospective cohort studies and registry data, preference was given to data obtained after propensity-score matching or statistical adjustment for risk-modulating variables over unadjusted data.

Synthesis of studies

Studies were grouped by interventions. An interdisciplinary expert group used their clinical experience to synthesise studies narratively by balancing beneficial and adverse effects extracted from the available evidence. Priority was given to diagnostic test accuracy, reducing mortality, immediate complications, and long-term adverse effects. Clinical heterogeneity was explored by comparing inclusion criteria and patient characteristics at baseline as well as clinical differences in the interventions and co-interventions.

Development and updating of recommendations

For each PICO question, the following updating options were available: (1) the recommendation of the preceding version remains valid and requires no changes ("confirmed"); (2) the recommendation requires modification ("modified"); (3) the recommendation is no longer valid or required and is deleted; (4) a new recommendation needs to be developed ("new"). An interdisciplinary expert group of clinicians with expertise in abdominal trauma, general surgery and visceral surgery reviewed the body of evidence, drafted recommendations based on the homogeneity of clinical characteristics and outcomes, the balance between benefits and harms as well as their clinical expertise, and proposed grades of recommendation (Table 2). In the absence of eligible evidence, good practice recommendations were made based on clinical experience, data from studies with a lower level of evidence, and expert consensus in cases where the Guideline Group felt a statement was required due to the

importance of the topic. These were not graded, and instead labelled as good (clinical) practice points (GPP). For GPPs, the strength of a recommendation is presented in the wording shown in Table 2.

Consensus process

The Guideline Group finalised the recommendations during a web-based, structured consensus conference on 14 June 2021 via Zoom (Zoom, Version: 5.x [Software]. Zoom Video Communications, Inc., San José, California, USA, https://zoom.us). A neutral moderator facilitated the conse nsus conference. Voting members of the Guideline Group were delegates of all participating professional organisations, including clinicians, emergency medical services personnel and nurses, while guideline methodologists attended in a supporting role. Members with a moderate, thematically relevant conflict of interest abstained from voting on recommendations, members with a high, relevant conflict of interest were not permitted to vote or participate in the discussion. Attempts to recruit patient representatives were unsuccessful. A member of the expert group presented recommendations. Following discussion, the Guideline Group refined the wording of the recommendations and modified the grade of recommendation as needed. Agreement with both the wording and the grade of recommendation was assessed by anonymous online voting using the survey function of Zoom. Abstentions were subtracted from the denominator of the agreement rate. Consensus strength was classified as shown in Table 3.

Recommendations were accepted if they reached consensus or strong consensus. For consensus recommendations with ≤95% agreement, diverging views by members of the Guideline Group were detailed in the background texts. Recommendations with majority approval were returned to the expert group for revision and further discussion at a subsequent consensus conference. Recommendations without approval were considered rejected.

External review

During a four-week consultation phase, the recommendations and background texts were submitted to all participating professional organisations for review. Comments were collected using a structured review form. The results were then assessed, discussed and incorporated into the text by the guideline coordinator with the relevant author group.

The guideline was adopted by the executive board of the German Trauma Society on 17 January 2023.

Table 3 Classification of consensus strength

Description	Agreement rate
strong consensus	>95% of participants
consensus	>75 to 95% of participants
majority approval	>50 to 75% of participants
no approval	<50% of participants

Quality assurance

The guideline recommendations were reviewed for consistency between guideline topic areas by the steering group. Where necessary, changes were made in collaboration with the clinical leads for all topic areas concerned. The final guideline document was checked for errors by the guideline chair and methodologist.

Results

The database searches identified 1459 unique records (Fig. 1). No additional records were obtained from clinical experts. Three studies were eligible for this update [10–12], adding to the body of evidence from the 66 studies previously included in the guideline [13–77]. A total of 57 full-text articles were excluded (Table S3, Online Resource 1).

Characteristics of studies included in this update

Study characteristics, main outcomes, levels of evidence, and risk-of-bias assessments are presented in Table 4. Full details are provided in Table S4, Online Resource 1. This update included two comparative registry studies [10, 11] and one prospective cohort study [12]. Two studies were performed in the United States [10, 11] and one in Taiwan [12]. Eligible patient populations were adults with blunt splenic [10] or hepatic [11, 12] trauma.

Risk-of-bias assessment for included studies and levels of evidence

The three studies included in the update showed an unclear risk of performance, selection and detection bias. The level of evidence was not downgraded for any study.

Recommendations

None of the recommendations were modified, one new recommendation was developed, and one was deleted. The recommendations were based on the updated evidence and expert consensus (Table 5). All achieved strong consensus (Table S5, Online Resource 1).

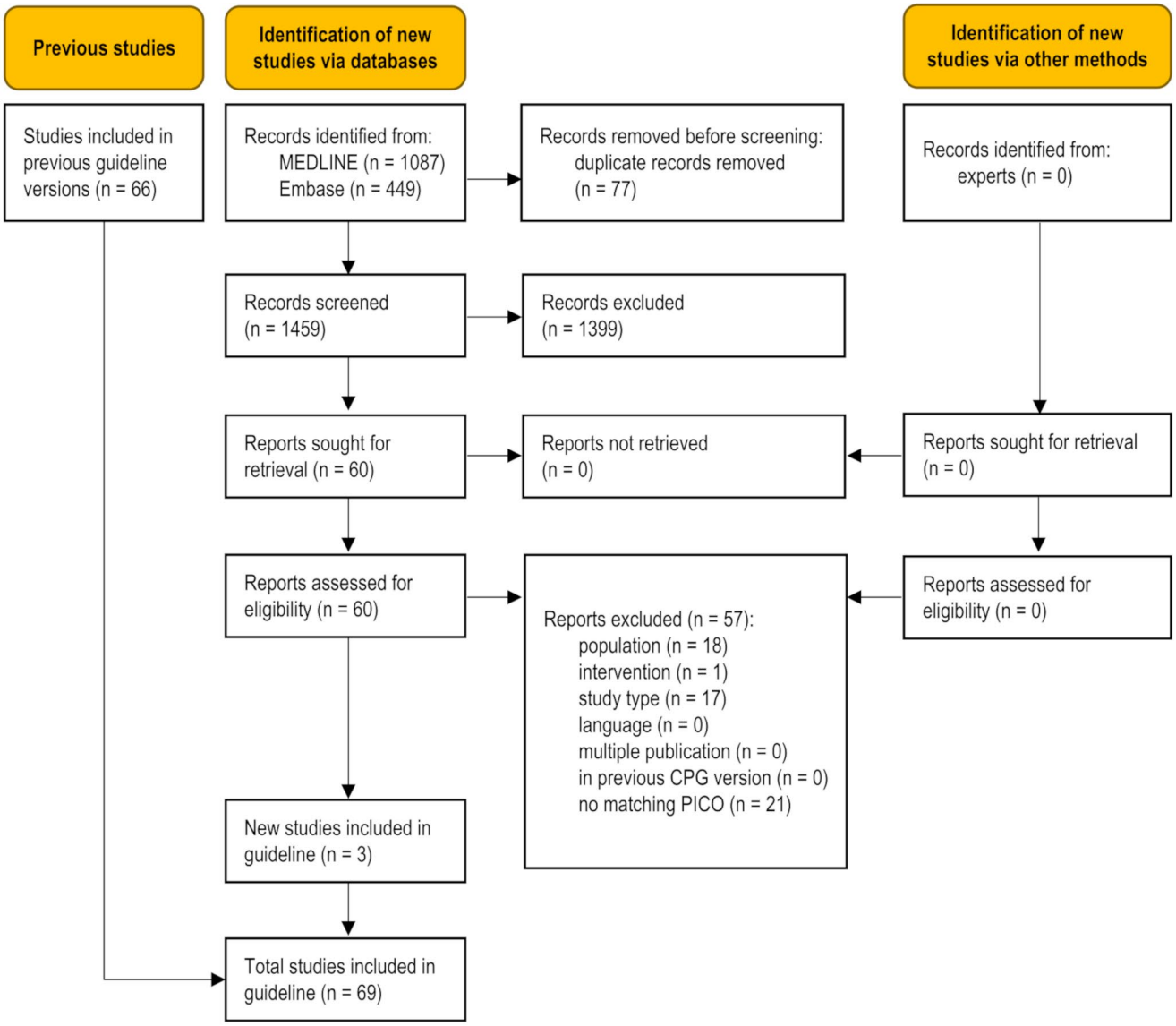

Fig. 1 Modified PRISMA 2020 flow diagram showing the systematic literature search and selection of studies

Discussion

Rationale for recommendations

For the first time, laparoscopy can be recommended for the management of abdominal trauma in haemodynamically stable patients with multiple trauma. This recommendation applies explicitly to penetrating abdominal trauma. Laparoscopy was reported to prevent non-therapeutic laparotomies in 45.6% of patients [81]. It is a safe and highly sensitive procedure that reduces postoperative morbidity without increasing mortality. Patients, however, must be haemodynamically stable. Laparoscopy can demonstrate peritoneal violation. If peritoneal violation or intra-abdominal injuries can be ruled out, patients with penetrating abdominal injuries do not require laparotomy. The therapeutic role of minimally invasive laparoscopy warrants further discussion, and recommendations regarding this method cannot be generated based on the available literature. There is a lack of randomised controlled trial data that could be compared in meta-analyses. Randomised controlled trials can hardly be performed in polytraumatised patients, especially in those who are haemodynamically unstable. As a result, the most important advantage of laparoscopy is the avoidance of non-therapeutic laparotomies.

In the previous guideline version, diagnostic peritoneal lavage (DPL) was only recommended in exceptional cases. In the updated guideline, this recommendation was completely deleted following a voting procedure because DPL is not used in clinical practice and is no longer considered

Table 4 Characteristics of studies included in the update

Study, reference	Design	Setting	Population	Age, ISS*	Interventions (*N* patients)	Main outcomes (selection)*	LoE, risk of bias (RoB)§, comments
Non-operative management of haemodynamically stable patients with isolated hepatic or splenic injuries							
Lewis 2021 [78]	Comparative registry study (TQIP Database)	USA, 2013–2016	Severely injured patients[a] (>16 years) with severe blunt splenic trauma (AIS≥3)	*Age [y], measurement n.r.* 36 (25–52) / 43 (28–56), $p<0.001$ *ISS* n.r.	$N=2643$ IG: no AE ($N=2351$) CG: AE ($N=292$)	*Deep venous thrombosisn (%)* IG: n.r. (1.4) CG: n.r. (4.5), $p<0.001$ On logistic regression, AE was found to be an independent risk factor for both DVT ($p<0.006$) or any VTE ($p<0.006$). Patients who underwent AE were more than twice as likely to develop these complications.	LoE 2b unclear RoB
Wong 2020 [79]	Prospective cohort study	Taiwan, 2013–2016	Severely injured patients[a] (≥20 years) with major blunt liver trauma (grade III and IV) treated by observation or embolisa-tion	*Mean age [y], (measurement n.r.)* 32.3 (±13.3) / 36.9 (±12.8) *Mean ISS (measurement n.r.)* 25.4 (±11.9) / 23.9 (±11.0)	$N=16$ IG: observation (no AE) ($N=7$) CG: AE ($N=9$)	*Mortality* There was no mortality. *Hepatic necrosis* No patient developed massive hepatic necrosis.	LoE 2b unclear RoB
Selective angioembolisation, laparotomy							
Samuels 2020 [80]	Comparative registry study (TQIP Database)	USA, 2016	Severely injured patients[a] (≥16 years) with grade III or higher blunt liver injury and stable vital signs[b]	*Median age [y] (IQR)* 36 (24–54) / 35 (24–54) *Median ISS (IQR)* 25 (18–30) / 25 (17–30), $p=0.001$	$N=1948$ ($N=339$ after propensity score matching) IG: hepatic AE within 24 h ($N=113$) CG: no hepatic AE ($N=226$)	*Inhospital mortality, n (%)* IG: 6 (5.4) CG: 7 (3.2), $p=0.48$	LoE 2b unclear RoB

* Data for IG versus CG unless otherwise specified. § Risk of bias: low RoB = RoB low for all domains; unclear RoB = RoB unclear for at least one domain, no high RoB in any domain; for studies with high RoB, all domains with high RoB are named, with RoB low or unclear for all other domains (for full details Table S4, Online Resource 1). [a] Severely injured patients defined as patients with an ISS≥16; [b] SBP≥90 mmHg and a heart rate of 50 and 110 bpm

Abbreviations: AE, angioembolisation; CG, control group; DVT, deep venous thrombosis; IG, intervention group; LoE, level of evidence; n.r., not reported; TQIP, Trauma Quality Improvement Program; VTE, venous thromboembolism

Table 5 List of recommendations with grade of recommendation and strength of consensus

No.	GoR	Evidence, consensus[a]	Recommendation	Status 2022
3	*Key recommendation* B ⇑		Laparoscopy can be safely performed in haemodynamically stable patients with penetrating abdominal trauma and can reduce the rate of non-therapeutic laparotomies.	New
1	B ⇑	100%	Midline laparotomy should be preferred over other approaches in the trauma setting.	Confirmed
2	B ⇑	100%	Damage control techniques (haemostasis, packing, temporary abdominal closure / laparostomy) should be preferred over attempts at definitive treatment in haemodynamically unstable patients with complex intra-abdominal damage.	Confirmed
4	B ⇑	100%	After damage control laparotomy, the abdomen should only be closed temporarily and not using fascial sutures.	Confirmed
5	B ⇑	100%	After packing for intra-abdominal haemorrhage control, a second-look operation should be performed between 24 and 72 h following the initial operative procedure.	Confirmed
6	B ⇑	100%	If a laparostomy has been created, the abdomen should be definitively closed as soon as possible.	Confirmed
Liver injuries				
7	B ⇑	100%	If possible, haemodynamically stable patients with isolated blunt hepatic or splenic injuries should be managed nonoperatively.	Confirmed
8	B ⇑	100%	If contrast-enhanced computed tomography provides evidence of arterial bleeding in a patient who has sustained a liver injury and can be haemodynamically stabilised, selective angioembolisation (if possible) or laparotomy should be performed.	Confirmed
Splenic injuries				
9	B ⇑	100%	Splenic injuries that require an intervention should be managed with selective angioembolisation rather than surgical haemostasis in patients who can be haemodynamically stabilised.	Confirmed
10	B ⇑	100%	If possible, AAST/Moore grade I–III splenic injuries that require surgery should be managed with a spleen-preserving procedure.	Confirmed
11	B ⇑	100%	Adult patients with AAST/Moore grade IV or V splenic injuries that require surgery should be managed with splenectomy rather than an attempt at spleen preservation.	Confirmed
Colon injuries				
12	A ⇑⇑	100%	Manage penetrating colon injuries with sutures or resection with a view to reducing the risk of intra-abdominal infections.	Confirmed

AAST, American Association for the Surgery of Trauma; GoR, grade of recommendation

state-of-the-art in Germany. Since a variety of alternative diagnostic procedures are available, there is no plausible explanation for the use of DPL.

All other recommendations on the diagnosis and treatment of abdominal trauma were confirmed in the updated guideline. As a result of the high rate of agreement with the existing recommendations and the difficulty to reach a high level of evidence, it can be assumed that the recommendations will continue to be valid in the long term.

Limitations of the guideline

Patient values and preferences were sought but not received. The effect of this on the guideline is unclear, and there is a lack of research evidence on the effect of patient participation on treatment decisions or outcomes in the emergency setting.

It is and probably will always be extremely difficult to reach a high level of evidence from studies that involve haemodynamically unstable patients with abdominal injuries. RCTs on these patients in a trauma setting are ethically unacceptable because of study design. For this reason, studies addressing for example the therapeutic effectiveness of minimally invasive techniques do not provide evidence at a level that meets the standards of an S3 guideline. As a result, such studies cannot be included. Continuing efforts must be made to generate high-quality evidence, and the need for studies that provide evidence of a high level and meet ethical requirements must be emphasised.

We would like to emphasize once again that the consistent and periodic review of high-quality studies for the regular updating of guidelines must always address open research questions. The challenges of a highly evidence-based evaluation of studies in trauma necessitate a focused approach to problem and question identification, which should ideally lead to studies that are, if possible, prospective and randomized, thus ensuring a high level of evidence.

Unanswered questions and future research

There are many unanswered questions about the management of abdominal trauma. For example, the role or potential benefit of serial abdominal FAST examinations following an initial normal CT scan must be investigated. Moreover, higher-level evidence concerning the optimisation of open abdomen management is becoming available. The Open

Abdomen Registry (www.ehs-openabdomen.com) is a useful tool that is increasingly being used to acquire and make available relevant data. The role of preventive angioembolisation in the management of splenic injuries should be addressed as well. Studies that investigate the therapeutic benefit of minimally invasive procedures and provide high-level evidence should be conducted and included in the guideline.

Abbreviations

AAST	American Association for the Surgery of Trauma
adj.	Adjusted
AE	Angioembolisation
AIS	Abbreviated Injury Scale
CG	Control group
DPL	Diagnostic peritoneal lavage
DVT	Deep venous thrombosis
FAST	Focused Assessment with Sonography for Trauma
GoR	Grade of recommendation
IG	Intervention group
ISS	Injury Severity Score
LoE	Level of evidence
n.r.	Not reported
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RCT	Randomised controlled trial
RR	Risk ratio
SBP	Systolic blood pressure
TQIP	Trauma Quality Improvement Program
unadj.	Unadjusted
VTE	Venous thromboembolism
y	Years

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Author contributions C.G. wrote the main manuscript textJ.B. prepared Tables 1, 2, 3 and 4, wrote textB.P. prepared Fig. 1; Table 5, wrote textR.S. wrote text mainly in the discussion.

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Data availability A full version of the guideline and its methods/evidence report are available online at https://register.awmf.org/de/leitlinien/detail/187-023.

Declarations

Ethics statement Ethical approval was not required because the study used publicly accessible documents as evidence.

Ethics statement None.

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