



Guideline

Chinese Guideline for the Diagnosis and Treatment of Head, Thoracic, Abdominal, and Pelvic Polytrauma (2026 Edition)



Jian-Ning Zhang^{1*} , Wang Jia², Yan-Bing Yu³, Jia-Yu Liu¹, Zhi-Qiang Xue⁴, Zhi Qiao⁵, Xiang-Dang Liang⁶, Xin Lou⁷, Wei-Dong Mi⁸, Tan-Shi Li⁹, Fei-Hu Zhou¹⁰, Gang Cheng¹, Jun-Zhao Sun¹, Wen-Ying Lv¹, De-Zhi Kang¹¹, Ning Wang¹², Rong-Cai Jiang¹², Jun-Ji Wei¹³, Guo-Yi Gao², Zhou Fei¹⁴, Hua Feng¹⁵, Hai-Yan Zhu⁹, Jiang-Bei Cao⁸, Ke-Zhong Chen¹⁶, Wei-Nan Liu¹⁷, Zhi-Yong Liu¹⁸, Yuan Gao¹⁹, Hua Yan²⁰, Yong-Xin Wang²¹, Jin-Fang Liu²², Liang Wen²³, Neurosurgery Specialist Alliance of the Joint Logistics Support Force, Neurotrauma Society of the China, International Exchange, Promotive Association for Medical, Health Care, Neurotrauma Group of the Chinese Congress of Neurological Surgeons, and Craniocerebral Trauma Panel of the Neurosurgery Society of the Beijing Medical Association

¹Senior Department of Neurosurgery, Chinese PLA General Hospital, Beijing, China; ²Department of Neurosurgery, Beijing Tiantan Hospital, Capital Medical University, Beijing, China; ³Department of Neurosurgery, China-Japan Friendship Hospital, Beijing, China; ⁴Department of Thoracic Surgery, the First Medical Center, Chinese PLA General Hospital, Beijing, China; ⁵Senior Department of General Surgery, Chinese PLA General Hospital, Beijing, China; ⁶Senior Department of Orthopedics, Chinese PLA General Hospital, Beijing, China; ⁷Department of Radiology, the First Medical Center, Chinese PLA General Hospital, Beijing, China; ⁸Department of Anesthesiology, the First Medical Center, Chinese PLA General Hospital, Beijing, China; ⁹Department of Emergency Medicine, the First Medical Center, Chinese PLA General Hospital, Beijing, China; ¹⁰Department of Critical Care Medicine, the First Medical Center, Chinese PLA General Hospital, Beijing, China; ¹¹Department of Neurosurgery, the First Affiliated Hospital of Fujian Medical University, Fuzhou, Fujian, China; ¹²Department of Neurosurgery, Xuanwu Hospital, Capital Medical University, Beijing, China; ¹³Department of Neurosurgery, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College, Beijing, China; ¹⁴Department of Neurosurgery, the First Affiliated Hospital of Air Force Medical University, Xi'an, Shaanxi, China; ¹⁵Department of Neurosurgery, Southwest Hospital, Army Medical University, Chongqing, China; ¹⁶Department of Thoracic Surgery, Peking University People's Hospital, Beijing, China; ¹⁷Department of General Surgery, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China; ¹⁸Department of Neurosurgery, West China Hospital, Sichuan University, Chengdu, Sichuan, China; ¹⁹Nursing Department, the First Medical Center, Chinese PLA General Hospital, Beijing, China; ²⁰Department of Neurosurgery, Huanhu Hospital Affiliated to Tianjin Medical University, Tianjin, China; ²¹Department of Neurosurgery, the First Affiliated Hospital of Xinjiang Medical University, Urumqi, Xinjiang, China; ²²Department of Neurosurgery, Xiangya Hospital, Central South University, Changsha, Hunan, China; ²³Department of Neurosurgery, the First Affiliated Hospital, Zhejiang University School of Medicine, Hangzhou, Zhejiang, China

Received: June 18, 2026 | Revised: July 24, 2026 | Accepted: August 10, 2026 | Published online: August 24, 2026

Abstract

Head, thoracic, abdominal, and pelvic polytrauma is clinically complex and requires coordinated multidisciplinary care, creating an urgent need for standardized guidance. This guideline aims to provide an evidence-based foundation and clinical pathway for the diagnosis, assessment, damage control, surgical timing, and acute-phase management of patients with head, thoracic, abdominal, and pelvic polytrauma. Led by the Senior Department of Neurosurgery, Chinese PLA General Hospital, a multidisciplinary working group comprising experts in thoracic surgery, general surgery, orthopedics, critical care medicine, anesthesiology, radiology, emergency medicine, nursing, and related disciplines developed the guideline through systematic review of the relevant literature, consideration of the characteristics of trauma care in China's military and civilian medical systems, and two rounds of expert voting and consensus decision-making. The guideline addresses 22 key clinical questions covering imaging assessment, damage-control resuscitation, prioritization of craniocerebral and torso injury management, anticoagulation and hemostatic management, intensive care, and early rehabilitation. A total of 22 recommendations were formulated by integrating evidence quality, clinical feasibility, and implementability, together with corresponding implementation points and quality-control indicators. The guideline emphasizes stabilization of vital signs, damage-control principles, multidisciplinary collaboration, standardized clinical pathways, and a tiered trauma-care system. Implementation

of these recommendations may improve the consistency and timeliness of multidisciplinary care and provide a framework for reducing early mortality while preserving neurological and functional outcomes.

Keywords: Polytrauma; Damage-control resuscitation; Diagnostic assessment; Surgical management; Multidisciplinary care; Clinical practice guideline.

***Correspondence to:** Jian-Ning Zhang, Senior Department of Neurosurgery, Chinese PLA General Hospital, Beijing 100853, China. ORCID: <https://orcid.org/0000-0003-1943-7045>. Tel: +86-13381207877, E-mail: jnzhang2018@163.com

How to cite this article: Zhang JN, Jia W, Yu YB, Liu JY, Xue ZQ, Qiao Z, *et al*. Chinese Guideline for the Diagnosis and Treatment of Head, Thoracic, Abdominal, and Pelvic Polytrauma (2026 Edition). *Neurosurgical Subspecialties*. Published online: Aug 24, 2026. DOI: 10.14218/NSSS.2026.00016.

Introduction

Head, thoracic, abdominal, and pelvic polytrauma is commonly caused by high-energy mechanisms, including combat-related injuries, high-speed road traffic crashes, and falls from height. Patients frequently present with complex injuries involving multiple anatomical regions and organ systems, such as cerebral contusions, lacerations, or intracranial hematomas; tension pneumothorax or flail chest; massive hemorrhage caused by hepatic or splenic rupture; and unstable pelvic fractures. The central pathophysiological challenge is the simultaneous and potentially fatal progression of hemorrhagic shock and intracranial hypertension. These conditions may further interact with the triad of hypothermia, acidosis, and coagulopathy, resulting in rapid deterioration from a potentially reversible state to irreversible physiological failure.

Traumatic injuries remain a major contributor to the global burden of disease and mortality. The number of injury-related deaths worldwide increased from approximately 4.26 million in 1990 to approximately 4.48 million in 2017,¹ and road traffic injuries remain a major cause of death and disability, particularly among younger populations.² According to the World Health Organization, approximately 1.19 million people die annually because of road traffic crashes. Road traffic injuries are the leading cause of death among children and young adults; more than 90% of related deaths occur in low- and middle-income countries, and vulnerable road users account for more than half of these deaths.³

Among major anatomical injury patterns, combined head, thoracic, abdominal, and pelvic trauma is associated with particularly high lethality. Traumatic brain injury and exsanguination remain the predominant causes of trauma-related death.⁴ Thoracic injury is independently associated with 30-day mortality. Approximately one-third of patients with trauma have thoracic injuries; such injuries occur in 10–15% of patients with unintentional trauma, account for approximately one-quarter of deaths among patients with severe trauma, and have been associated with mortality rates of up to 60% in some studies.^{5,6} Thoracoabdominal trauma combines injuries to the chest and abdomen, is associated with severe physiological disruption and substantial mortality, and has increased in incidence in some settings.⁷ In China, trauma is the fifth leading cause of death and the leading cause of death among youths.⁸ Injury prevention and control remain major public health priorities.⁹

The mechanisms of death differ according to the injured ana-

tomical region. Traumatic brain injury remains a principal cause of trauma-related death, whereas severe torso injuries may lead to early death through respiratory compromise or uncontrolled hemorrhage.^{4,7} These epidemiological and pathophysiological characteristics provide the basis for a management strategy centered on both hemorrhage control and cerebral protection.

Emergency management therefore requires parallel strategies from the earliest phase of care: life-threatening hemorrhage must be controlled as rapidly as possible, while cerebral protection and decompression should be initiated at the earliest appropriate time. However, previous guidelines have generally been organized according to individual anatomical regions or specific clinical topics and have not provided an integrated pathway for patients with multisystem head, thoracic, abdominal, and pelvic injuries. This fragmentation may contribute to variability in imaging strategies, resuscitation targets, prioritization of hemorrhage-control and neurosurgical procedures, anticoagulation management, and multidisciplinary coordination.

This guideline integrates current evidence and multidisciplinary expert consensus across the continuum from prehospital management to acute in-hospital care. It focuses on early assessment, hemostatic resuscitation, damage-control surgery, prioritization of craniocerebral and torso interventions, perioperative management, special populations, and prognostic assessment. The guideline is intended primarily for adult patients with confirmed or highly suspected concomitant head, thoracic, abdominal, and pelvic injuries and emphasizes key decisions during the first 24–48 h of care. By providing 22 clear and operational recommendations, it aims to support rapid, coordinated, and evidence-informed multidisciplinary intervention within the critical treatment window.

Methods and guideline development process

Methodological framework

This guideline was developed using a systematic review approach in accordance with the principles of evidence-based medicine and generally accepted standards for clinical practice guideline development. The guideline-development process referred to relevant guideline-reporting standards and the Appraisal of Guidelines for Research and Evaluation II framework. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach was used to rate the certainty of evidence and determine the strength of recommendations (Table 1).

An evidence-to-decision framework was applied to consider the certainty and magnitude of the available evidence, the balance between benefits and harms, resource requirements and costs, accessibility and equity, feasibility, and acceptability. Conventional GRADE strength categories were interpreted as strong or conditional. In addition, this guideline predefined category III as a guideline-specific operational category for time-critical, life-threatening scenarios in which direct evidence was limited, the risk of delaying action was substantial, feasibility was acceptable,

Table 1. Definitions of GRADE evidence quality and strength of recommendations

Item	Grade	Definition
Quality of evidence	High (A)	Consistent findings from high-quality randomized controlled trials or systematic reviews; further research is very unlikely to change the conclusion
Quality of evidence	Moderate (B)	Evidence from limited randomized controlled trials or high-quality observational studies, or evidence with certain limitations; further research may change the conclusion
Quality of evidence	Low (C)	Evidence is primarily derived from observational studies and has a substantial risk of bias; further research is likely to change the conclusion
Quality of evidence	Very low (D)	Evidence is highly insufficient or is based only on expert experience; consensus may be strong, but supporting data are lacking
Strength of recommendation	Strong recommendation (I)	Supported by clear evidence or highly consistent expert consensus; clinical benefits clearly outweigh risks and costs, and the recommendation is applicable to most patients and clinical settings
Strength of recommendation	Weak recommendation (II)	Evidence is limited or uncertain; decisions should be individualized according to patient preferences, resource availability, and institutional conditions
Strength of recommendation	Guideline-specific operational category: conditional strong recommendation (III)	Formulated when the quality of evidence is very low but the potential clinical harm is clear and expert consensus is highly consistent, such as in life-threatening emergency situations

Category III is a guideline-specific operational category and is not a standard GRADE recommendation-strength category. GRADE, Grading of Recommendations Assessment, Development and Evaluation.

and multidisciplinary agreement was high. Category III does not represent an additional conventional GRADE category and should not be interpreted as equivalent to a conventional strong recommendation outside its stated prerequisites.

Conflict-of-interest management was implemented throughout guideline development. All participating experts completed conflict-of-interest declarations. Experts with a relevant potential conflict were required to abstain from the corresponding discussion and voting process.

Guideline development group and panel composition

The guideline was initiated and coordinated by the Senior Department of Neurosurgery, Chinese PLA General Hospital. The guideline development group comprised 95 multidisciplinary experts from military and civilian tertiary hospitals and trauma-related medical centers across multiple provinces and municipalities in China.

The panel included specialists in neurosurgery, thoracic surgery, general surgery, hepatobiliary and pancreatic surgery, orthopedics and trauma surgery, emergency medicine, critical care medicine, anesthesiology, diagnostic and interventional radiology, rehabilitation, and nursing. Experts were selected to ensure appropriate multidisciplinary and geographical representation and on the basis of their clinical expertise, academic experience, and active involvement in the management of severe trauma or related guideline-development activities.

The organizational structure consisted of a steering group, a methodology and evidence-assessment group, a writing group, a secretariat, and an external review group. The steering group

supervised the scope and overall development of the guideline. The methodology and evidence-assessment group conducted the literature review, assessed the certainty of evidence, and prepared evidence summaries. The writing group drafted and revised the recommendations and supporting text. The external review group independently reviewed the methodological rigor, clinical applicability, and clarity of the draft guideline.

Scope and target population

This guideline is intended for medical institutions and multidisciplinary teams responsible for the management of adult patients with confirmed or highly suspected injuries involving at least two of the head, thorax, abdomen, and pelvis. It primarily addresses critical decisions during the first 24–48 h of prehospital and in-hospital care.

Target users include clinicians and healthcare professionals working in trauma centers, emergency departments, neurosurgery, thoracic surgery, general and hepatobiliary-pancreatic surgery, orthopedics, anesthesiology, critical care medicine, radiology and interventional radiology, rehabilitation, nursing, and patient transport services.

Patients with high-energy injury mechanisms, neck or back pain or tenderness, any neurological deficit, or an unreliable physical examination should be managed according to spinal protection protocols and should undergo multidisciplinary assessment as early as possible.

At primary-level institutions, priorities should include control of massive hemorrhage; assessment according to the exsanguination control, airway/cervical spine protection, breathing, circula-

tion, disability, and exposure (X-ABCDE) sequence; management of life-threatening hemorrhage and thoracic emergencies; shock resuscitation; and rapid transport. Trauma centers should conduct parallel multidisciplinary assessments and damage control resuscitation early after admission and should follow a pathway-based decision-making process (Fig. 1).

Patients with an injury confined to a single anatomical region or a single clinical problem should preferentially be managed according to the relevant specialty guideline. Children, pregnant or postpartum patients, and other special populations require individualized management with reference to the corresponding specialty guidance and local resources. The operational definitions of severe head, thoracic, and abdominal injuries and hemodynamic instability used in this guideline are presented in Table 2.

Formulation of clinical questions

Potential clinical questions were identified through semi-structured interviews with multidisciplinary experts. The questions addressed early assessment, imaging strategies, resuscitation and damage control, prioritization of craniocerebral and torso interventions, perioperative management, special populations and circumstances, and the coordinated treatment of life-threatening thoracic, abdominal, and pelvic injuries.

Candidate questions were structured according to the population, intervention, comparator, and outcome framework. The clinical importance, degree of uncertainty or variation in practice, availability of evidence, and potential influence on patient outcomes were considered during question selection. Following expert review and two rounds of Delphi revision, 22 clinical questions were retained. A predefined agreement threshold of at least 80% was required for inclusion.

Literature search

PubMed/MEDLINE, Embase, the Cochrane Library, Web of Science, the China National Knowledge Infrastructure, the Wanfang database, and the VIP database were searched from database inception through December 1, 2025. A final supplementary search was completed on January 31, 2026, to identify newly available and online-ahead-of-print records. Searches were restricted to English- and Chinese-language records.

Controlled vocabulary terms and free-text terms were combined. The searches covered polytrauma, traumatic brain injury (TBI), thoracic injury, abdominal and pelvic injury, damage control resuscitation, massive transfusion protocols, hemostatic treatment, interventional procedures, venous thromboembolism and deep vein thrombosis prevention, perioperative management, rehabilitation, clinical pathway optimization, and prognostic assessment. Landmark studies required to support major recommendations were retained together with the most recent relevant evidence.

Eligible evidence included formally published clinical practice guidelines, systematic reviews and meta-analyses, randomized controlled trials, quasi-experimental studies, prospective and retrospective cohort studies, case-control studies, and diagnostic accuracy studies. Studies were eligible when they enrolled adults with polytrauma or investigated an individual component injury or intervention that was directly relevant to the integrated management of head, thoracic, abdominal, or pelvic trauma.

Studies were excluded when they were unrelated to the prespecified clinical questions, focused exclusively on minor isolated injuries without relevance to polytrauma management, did not report clinically relevant outcomes, represented duplicate publications, were available only as conference abstracts, or did not provide sufficient information for evidence assessment. Narrative opinions and individual case reports without generalizable evidence were not used to determine recommendation strength. Studies involving children or pregnant patients were used only when they provided evidence applicable to general trauma-management principles.

Study selection and evidence synthesis

The search identified 24,913 records, including 6,842 from PubMed/MEDLINE, 7,965 from Embase, 482 from the Cochrane Library, 5,231 from Web of Science, 2,143 from the China National Knowledge Infrastructure, 1,287 from the Wanfang database, and 963 from the VIP database.

After removal of duplicates, 17,406 records underwent title and abstract screening. A total of 15,812 records were excluded during this stage. The remaining 1,594 reports underwent full-text assessment, of which 1,204 were excluded. Ultimately, 390 publications were included in the evidence review and, where appropriate, quantitative synthesis.

The included literature comprised 358 original studies, including 28 randomized controlled trials, 42 quasi-experimental or before-and-after controlled studies, 196 cohort studies, 57 case-control studies, and 35 diagnostic studies. An additional 32 systematic reviews or meta-analyses were included to support background interpretation and sensitivity assessment.

Screening was conducted independently by members of the methodology and evidence-assessment group. Records for which eligibility was uncertain were discussed by the reviewers. Disagreements that could not be resolved through discussion were referred to a senior member of the methodology group for adjudication. Reasons for exclusion at the full-text stage were documented.

Evidence was synthesized according to the prespecified clinical questions. When direct evidence concerning combined head, thoracic, abdominal, and pelvic polytrauma was unavailable, evidence from the corresponding component injuries was considered, and the potential indirectness of the evidence was reflected in the GRADE assessment.

Risk-of-bias assessment and evidence grading

Randomized controlled trials were evaluated using the revised Cochrane risk-of-bias tool. Nonrandomized intervention studies were assessed using the Risk of Bias in Non-randomized Studies of Interventions tool. Diagnostic accuracy studies were assessed using the Quality Assessment of Diagnostic Accuracy Studies tool, and systematic reviews were evaluated using the Assessment of Multiple Systematic Reviews tool.

The certainty of evidence was classified as high, moderate, low, or very low using GRADE. The assessment considered risk of bias, inconsistency, indirectness, imprecision, and publication bias. The strength of each recommendation was determined by integrating the certainty of evidence with the anticipated benefits and harms, resource requirements, feasibility, accessibility, equity, and acceptability.

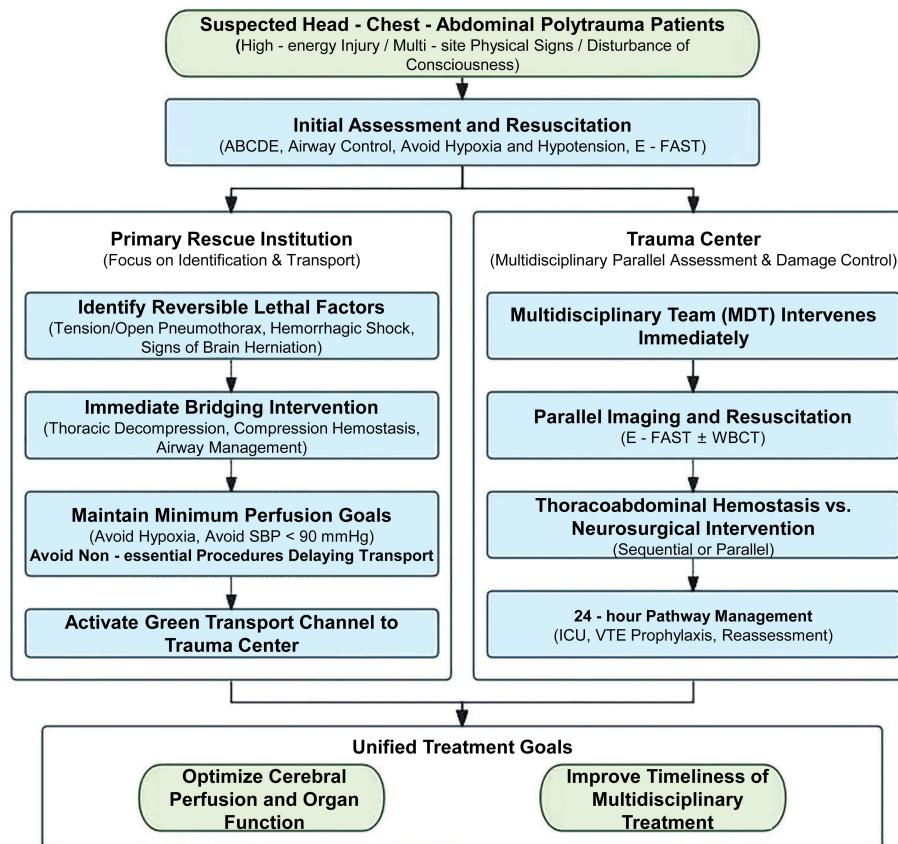


Fig. 1. Tiered management pathway for head, thoracic, abdominal, and pelvic polytrauma across different levels of medical institutions. ABCDE, airway/cervical spine, breathing, circulation, disability, and exposure; E-FAST, extended focused assessment with sonography for trauma; SBP, systolic blood pressure; WBCT, whole-body computed tomography; ICU, intensive care unit; VTE, venous thromboembolism.

Development of recommendations and Delphi consensus

The writing group drafted the initial recommendations based on the evidence summaries and evidence-to-decision assessments. Draft recommendations were reviewed by the multidisciplinary panel through two Delphi rounds.

Experts rated each recommendation using a 5-point Likert scale: 1, strongly disagree; 2, disagree; 3, uncertain; 4, agree; and 5, strongly agree. Agreement was defined as a rating of 4 or 5. Consensus was predefined as agreement by at least 80% of valid respondents.

After the first Delphi round, quantitative voting results and written comments were collated by the secretariat. Recommendations that required clarification or did not achieve sufficient agreement were revised by the writing and methodology groups after reassessment of the supporting evidence. The revised recommendations were then circulated for a second Delphi round.

Differences of opinion were addressed through structured multidisciplinary discussion. When disagreement related to interpretation of the evidence, the methodology group reassessed the relevant evidence summary. When disagreement related to clinical applicability, wording was revised to clarify the target population, prerequisites, exceptions, or implementation conditions. No recommendation was retained unless it achieved

the predefined consensus threshold.

All 22 final recommendations achieved at least 80% agreement. The number of valid votes and the exact agreement percentage for each recommendation are reported in Table 3.

External review and final approval

The draft guideline underwent external expert review and methodological review. The external reviewers assessed the scope, methodological rigor, interpretation of evidence, clarity of the recommendations, clinical feasibility, and potential risks associated with implementation.

Comments were reviewed by the steering, methodology, and writing groups. The manuscript and recommendation wording were revised where appropriate, and major revisions were recirculated to the relevant experts for confirmation. The final guideline and all 22 recommendations were reviewed and approved by the guideline development group.

Early diagnosis and assessment of head, thoracic, abdominal, and pelvic polytrauma

To provide a clear representation of the complete pathway from hospital admission to key clinical decisions, the principal stages of management were summarized in an overall treatment algorithm

Table 2. Terminology and scope: Operational definitions of severe head, thoracic, and abdominal injuries used in this guideline

Term	Score	Operational definition
Severe head injury	Head AIS score ≥ 3 ¹⁰⁻¹²	(1) A post-resuscitation GCS score of 3–8 should be managed according to the severe TBI pathway, including cerebral perfusion pressure monitoring and neurosurgical consultation. ^{13,14} (2) A post-resuscitation GCS score > 8 accompanied by progressive neurological deterioration or signs of cerebral herniation. (3) Abnormal findings on head CT, including hematoma, cerebral contusion or laceration, diffuse cerebral swelling, cerebral herniation, or compression or obliteration of the basal cisterns, when associated with injury severity and the need for escalation of intervention ^{13,14}
Severe thoracic injury	Thoracic AIS score ≥ 3 ^{10,11,15}	(1) An immediately life-threatening thoracic injury requiring emergency intervention, including tension pneumothorax, cardiac tamponade, open pneumothorax, massive hemothorax, or ongoing intrathoracic hemorrhage. (2) Severe hypoxemia or respiratory failure caused by thoracic injury and requiring mechanical ventilation. (3) Imaging evidence of a high-risk thoracic injury accompanied by progressive hypoxemia, shock, or an ongoing requirement for transfusion or vasopressor support
Severe abdominal injury	Abdominal AIS score ≥ 3 ^{10,11}	(1) Hemodynamic instability or a transient response to resuscitation with suspected intra-abdominal hemorrhage, supported by a positive or strongly suspected positive E-FAST examination, requiring entry into a definitive hemorrhage-control pathway involving damage-control surgery or an interventional procedure. (2) A solid-organ injury associated with an ongoing transfusion requirement, hemodynamic deterioration, or imaging evidence of active bleeding, requiring assessment for escalation to an interventional or surgical procedure. (3) Hollow-viscus perforation, signs of peritonitis, or imaging evidence of free intraperitoneal gas or major mesenteric injury, requiring surgical exploration and treatment
Hemodynamic instability	Not applicable	An SBP < 90 mmHg is the most commonly used threshold for hemodynamic instability in adult trauma patients. The patient's response to initial resuscitation, transfusion requirements, shock index, and other clinical signs of hypoperfusion should also be considered ¹⁶

AIS, Abbreviated Injury Scale; CT, computed tomography; E-FAST, extended focused assessment with sonography for trauma; GCS, Glasgow Coma Scale; SBP, systolic blood pressure; TBI, traumatic brain injury.

(Fig. 2). This algorithm encompasses primary assessment, triage decisions, and definitive management.

Primary assessment

Clinical question 1: In adults with suspected severe head, thoracic, abdominal, and pelvic polytrauma, what sequence should guide the immediate primary assessment and life-saving interventions?

Recommendation 1: In patients with suspected severe head, thoracic, abdominal, and pelvic polytrauma, primary assessment and management should be initiated immediately according to the X-ABCDE sequence in the prehospital setting or upon arrival in the emergency department. Continuous reassessment and reprioritization should be performed according to the principle of “life-saving interventions first, comprehensive evaluation thereafter”. Provided that life-saving interventions are not delayed, patients should be transferred to a definitive hemorrhage-control, surgical, or interventional pathway as rapidly as possible. Clinically suspected tension pneumothorax should be decompressed immediately without awaiting imaging confirmation. In patients with an open pneumothorax, the chest-wall defect should be sealed immediately, followed by

tube thoracostomy as soon as possible.

Strength of recommendation: I, strong recommendation

Quality of evidence: C, low

Rationale for recommendation strength: Although the certainty of direct comparative evidence is low, immediate control of exsanguinating hemorrhage and life-threatening airway or thoracic compromise addresses a clear risk of preventable death, is consistent with established trauma-care principles, is feasible across care settings, and achieved unanimous panel agreement.

The primary assessment should follow an X-ABCDE sequence, in which control of exsanguinating hemorrhage is placed before the conventional Advanced Trauma Life Support ABCDE primary survey.¹⁷ “X” represents the control of exsanguinating hemorrhage. In the prehospital setting and upon hospital admission, massive extremity hemorrhage should be managed using a step-wise approach comprising manual compression, a pressure dressing with or without an adjunctive hemostatic agent, and application of a tourniquet. The time of tourniquet application should be documented, and conversion to another method should be reassessed after hemodynamic stabilization.

In patients with penetrating thoracic or abdominal injury, when the foreign body has been removed and the wound is ≥ 3 cm, packing with a chitosan-based hemostatic agent may be con-

Table 3. Structured map of the 22 clinical questions and recommendations

No.	Clinical question / topic	Key recommendation	Prerequisites or exceptions	Strength	Evidence quality	Agreed Votes / Total Valid Votes, Agreement Percentage
1	Primary assessment	Immediately initiate X-ABCDE assessment and management in the prehospital or emergency setting, with dynamic reassessment according to the principle of life-saving intervention before comprehensive evaluation	Tension or open pneumothorax should be treated without awaiting imaging; definitive hemorrhage-control, surgical, or interventional pathways should be established as rapidly as possible	I	C	92/92, 100%
2	Whole-body CT	Perform whole-body CT as early as possible after criteria for safe transport have been met to improve efficiency and reduce missed injuries and repeated transfers	The patient must meet criteria for safe transport	II	B	92/92, 100%
3	Integrated whole-body CT and imaging sequence	In patients with a low GCS score, an unreliable examination, or a high-risk injury mechanism, prioritize integrated whole-body CT. When immediate hemorrhage control or decompression is required, life-saving intervention should precede imaging	Imaging should be deferred when immediately fatal hemorrhage or an otherwise irreversible injury requires urgent intervention	III	B	92/92, 100%
4	Metabolic indices	Include lactate and base excess in routine admission testing and perform serial measurements to identify occult hypoperfusion; these indices should not replace clinical or imaging assessment	These indices are supplementary and should not be used as the sole basis for diagnosis	II	C	92/92, 100%
5	Massive transfusion protocol ratios	When a massive transfusion protocol is activated, use balanced transfusion with plasma, platelets, and red blood cells at a ratio of 1:1:1 or 1:1:2. Correct hypothermia, acidosis, and hypocalcemia, supplement fibrinogen, and restrict crystalloid administration concurrently	Evidence is more consistent for reduced hemorrhage-related mortality within 24 h; evidence regarding 30-day all-cause mortality is inconsistent	I	B	91/92, ~98.9%
6	Fibrinogen	Monitor and correct fibrinogen early in severe hemorrhage, targeting 1.5–2.0 g/L. If fibrinogen is <1.5 g/L, administer fibrinogen concentrate or cryoprecipitate immediately	Earlier intervention may be considered when fibrinogen is 1.5–2.0 g/L but bleeding persists or the patient remains at high risk	I	B	92/92, 100%
7	Tranexamic acid	Administer tranexamic acid as early as possible, including in the prehospital setting when appropriate, in patients with active bleeding or a high risk of bleeding. The initial dose should be given within 3 h after injury	Benefits are more consistent in mild-to-moderate TBI; patients with severe TBI, defined as a GCS score of 3–5, or treatment initiated after 3 h require individualized	I	A	92/92, 100%

Table 3. Structured map of the 22 clinical questions and recommendations (continued)

No.	Clinical question / topic	Key recommendation	Prerequisites or exceptions	Strength	Evidence quality	Agreed Votes / Total Valid Votes, Agreement Percentage
			assessment			
8	Stratified blood-pressure targets	Permissive hypotension with an SBP of 80–90 mmHg may be used for hemorrhagic shock without TBI. It should not be used in severe TBI; MAP should be maintained at ≥ 80 mmHg, SBP at ≥ 110 mmHg, or CPP at 60–70 mmHg	The key stratification factor is the presence or absence of severe TBI, defined as a GCS score ≤ 8	II	D	92/92, 100%
9	Intensity of resuscitation	Avoid excessively aggressive fluid resuscitation because of its association with acute lung injury, acute respiratory distress syndrome, and adverse outcomes. Use restrictive fluids, rapid hemorrhage control, and balanced resuscitation	Indiscriminate administration of large volumes of crystalloids or blood products should be avoided before hemorrhage is controlled	II	D	92/92, 100%
10	Resuscitative endovascular balloon occlusion of the aorta	Routine REBOA is not advised. It should be reserved for extreme life-saving situations as a brief bridge to definitive hemorrhage control, with strict indications, time limits, and an experienced team	It may be considered only when circulation cannot be stabilized despite a massive transfusion protocol, tranexamic acid, pelvic binding, and other fundamental measures	III	D	92/92, 100%
11	Torso hemorrhage with intracranial hypertension	When fatal hemorrhage and intracranial hypertension coexist, prioritize control of life-threatening hemorrhage and perform decompression as rapidly as circumstances permit. Parallel dual-team procedures are preferred when feasible, and bridging decompression may be used to gain time	In the presence of cerebral herniation or impending herniation, staged decompression may precede immediate hemorrhage control	III	D	92/92, 100%
12	Deep vein thrombosis prophylaxis	Initiate low-molecular-weight heparin as early as possible after head CT findings are stable. In patients with TBI and polytrauma, initiation within 24–72 h together with mechanical prophylaxis and perioperative reassessment is suggested	Stable imaging findings are required, and bleeding risk must be assessed individually	II	C	90/92, ~97.8%
13	Seizure prophylaxis	Provide 7 days of prophylactic antiseizure treatment for severe TBI; treatment beyond 7 days is not advised. Levetiracetam or phenytoin/fosphenytoin may be selected; lacosamide may be considered as an alternative based on limited observational evidence	Selection should consider adverse effects, drug interactions, and availability	I	B	92/92, 100%
14	Early rehabilitation	After imaging findings and vital signs have stabilized, initiate carefully	Stability is required, and rehabilitation should	II	C	92/92, 100%

Table 3. Structured map of the 22 clinical questions and recommendations (continued)

No.	Clinical question / topic	Key recommendation	Prerequisites or exceptions	Strength	Evidence quality	Agreed Votes / Total Valid Votes, Agreement Percentage
		staged early rehabilitation within 48 h to facilitate functional recovery and potentially shorten hospitalization. Rehabilitation should be individualized and progressively advanced with appropriate monitoring	be noninvasive and progressively advanced			
15	Sequencing of hemorrhage-control and intracranial surgery	Prioritize control of uncontrolled thoracic, abdominal, or pelvic hemorrhage. When circulation is relatively stable but an intracranial hypertensive crisis is present, prioritize decompression or hematoma evacuation. Simultaneous treatment may be considered when feasible	The sequence should be adjusted dynamically according to whether hemorrhage is uncontrolled and whether intracranial hypertension constitutes an immediate crisis	I	D	92/92, 100%
16	Decompressive craniectomy	Decompressive craniectomy may reduce mortality in refractory intracranial hypertension but may increase severe disability. Full communication is required, early low-threshold use should be avoided, and space-occupying hematomas should be treated primarily by evacuation with or without decompression	A typical indication is ICP >22 mmHg with failure of second-line treatment and an immediate threat to life	I	B	92/92, 100%
17	Thoracic hemorrhage pathway	Follow a stepwise pathway of chest-tube placement and quantification followed by rapid triage to video-assisted thoracoscopic surgery, thoracotomy, or embolization. Chest-tube placement alone should not substitute for definitive control of active bleeding	Multidisciplinary parallel management should be used to shorten the interval from recognition to hemorrhage control	I	C	92/92, 100%
18	Life-threatening thoracic injury with TBI	Rapidly manage tension pneumothorax, cardiac tamponade, and other life-threatening thoracic injuries to restore ventilation and circulation while rigorously avoiding hypoxemia and hypotension. Without ICP monitoring, maintain SBP ≥110 mmHg or MAP ≥80 mmHg	When ICP can be monitored, management should be guided by the CPP target	I	C	92/92, 100%
19	Simultaneous dual-team surgery	At centers with a hybrid operating room, simultaneous dual-team surgery may be considered individually to shorten the intervention window, but the evidence is of very low quality and routine use is not advised	Sequential surgery combined with damage-control principles remains appropriate in most circumstances	II	D	92/92, 100%
20	Geriatric polytrauma	Implement a geriatric trauma pathway incorporating a higher warning threshold for hypotension, frailty screening, and assessment and management of anticoagulant therapy to improve recognition and	Goals of care and patient preferences should be respected	I	B	91/92, ~98.9%

Table 3. Structured map of the 22 clinical questions and recommendations (continued)

No.	Clinical question / topic	Key recommendation	Prerequisites or exceptions	Strength	Evidence quality	Agreed Votes / Total Valid Votes, Agreement Percentage
		outcomes				
21	Battlefield hemorrhage control	In battlefield hot or warm zones, prioritize immediate hemorrhage control using appropriate tourniquets, junctional hemorrhage-control devices, hemostatic dressings, or other suitable methods, together with early antishock management	Recommendations are supported by consistent operational medical guidance and large observational studies	I	B	92/92, 100%
22	Prognostic prediction tools and artificial intelligence	Use prediction tools for risk stratification and communication rather than for precise individual prognostication. CRASH and IMPACT are foundational statistical models; machine-learning and deep-learning approaches may serve as supplementary tools but require external validation and clinical-impact assessment	These tools should support decision-making; final decisions must integrate clinical findings and patient preferences	II	B	92/92, 100%

CPP, cerebral perfusion pressure; CRASH, Corticosteroid Randomisation After Significant Head Injury; CT, computed tomography; GCS, Glasgow Coma Scale; ICP, intracranial pressure; IMPACT, International Mission for Prognosis and Analysis of Clinical Trials in TBI; MAP, mean arterial pressure; REBOA, resuscitative endovascular balloon occlusion of the aorta; SBP, systolic blood pressure; TBI, traumatic brain injury; X-ABCDE, exsanguination control, airway/cervical spine protection, breathing, circulation, disability, and exposure.

sidered according to resource availability. In patients with suspected pelvic-ring instability, a pelvic binder should be applied immediately. The potential need for resuscitative endovascular balloon occlusion of the aorta (REBOA) or emergency exploratory laparotomy should subsequently be assessed. Early application of a pelvic binder may reduce transfusion requirements during resuscitation.¹⁷

For airway and breathing management, rapid-sequence intubation should be used when indicated, and videolaryngoscopy should be considered to improve first-pass success in patients at risk of airway compromise.¹⁸ A difficult airway should be anticipated, and a backup strategy should be prepared. If 2 attempts at endotracheal intubation are unsuccessful, an alternative ventilation strategy should be implemented immediately.^{19,20} End-tidal carbon dioxide should be continuously monitored. Tension pneumothorax should be treated with immediate thoracic decompression on the basis of clinical diagnosis.^{21,22}

When chest-wall thickness is assessed, additional thickness resulting from trauma-related soft-tissue swelling and hemorrhage should be considered. The length of the decompression device should be selected according to the patient's body habitus, estimated chest-wall thickness, treatment environment, and specific injury characteristics, including the extent of

soft-tissue contusion and edema.

In adults, large-bore needle decompression at the fourth or fifth intercostal space in the anterior or midaxillary line is recommended, using a needle or catheter of ≥ 14 G and ≥ 8 cm in length. Finger thoracostomy or simple thoracostomy may alternatively be performed, followed as soon as possible by placement of a chest tube.¹⁷ The 10th edition of *Advanced Trauma Life Support* places particular emphasis on this site, especially in patients with obesity or a thick chest wall.¹⁷ The second intercostal space at the midclavicular line remains an alternative site. Because a standard 5-cm needle may fail to reach the pleural cavity in some adults, a needle ≥ 7 cm in length or ultrasound-guided decompression is recommended.¹⁷ The emergency management pathway for tension pneumothorax is summarized in [Figure 3](#).

In patients with an open pneumothorax, the chest-wall defect should be covered immediately with an occlusive dressing, such as a dressing secured on 3 sides. A chest tube should subsequently be inserted as soon as possible at a site away from the wound.

For circulatory support, 2 large-bore intravenous access lines should be established as rapidly as possible, preferably through upper-extremity peripheral veins using catheters of ≥ 18 G.^{23,24} If peripheral access is difficult to obtain or rapid massive transfusion is required, intraosseous

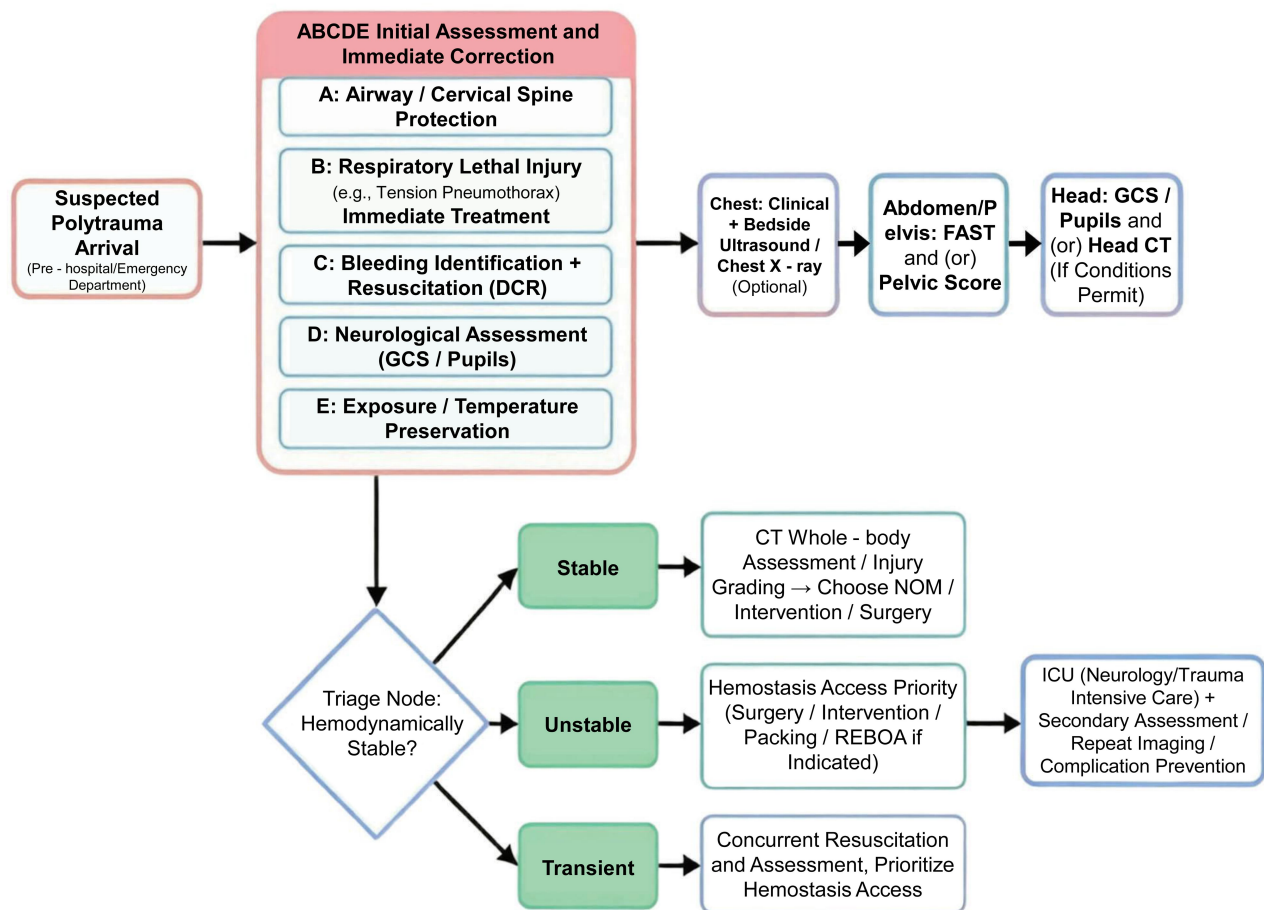


Fig. 2. Overall management algorithm for head, thoracic, abdominal, and pelvic polytrauma. ABCDE, airway and cervical spine protection, breathing, circulation, disability, and exposure; CT, computed tomography; DCR, damage control resuscitation; FAST, focused assessment with sonography for trauma; GCS, Glasgow Coma Scale; ICU, intensive care unit; NOM, nonoperative management; REBOA, resuscitative endovascular balloon occlusion of the aorta.

access or a large-bore central venous catheter should be established promptly.

Damage control resuscitation should be initiated according to the patient's condition. Restrictive fluid resuscitation is advocated for isolated hemorrhagic shock, whereas hypoperfusion should be avoided in patients with concomitant severe TBI. When intracranial pressure (ICP) monitoring is available, cerebral perfusion pressure (CPP) should be maintained at 60–70 mmHg. When ICP cannot be monitored, this guideline uses a mean arterial pressure (MAP) of ≥ 80 mmHg whenever possible or a systolic blood pressure (SBP) of ≥ 110 mmHg as a conservative bedside minimum during emergency management. Factors contributing to secondary brain injury, including hypoxemia, hypotension, and hypercapnia, should be corrected as a priority.^{13,14}

Assessment of disability should include rapid evaluation and documentation of the Glasgow Coma Scale (GCS) score (Table 4). When available, quantitative pupillometry is recommended to provide objective measurements. If new or progressive anisocoria, an abnormal pupillary light response, or substantial deterioration in quantitative pupillary indices is observed, neurosurgical

consultation should be obtained immediately and the ICP management pathway should be initiated while hypoxemia and hypotension are corrected.^{13,14} Pupillary abnormalities may also result from a local ocular injury.

In patients with a high-energy injury mechanism, neck or back pain or tenderness, a neurological deficit, or an unreliable physical examination, spinal injury should be considered not yet excluded. Spinal protection and immobilization should be maintained, and orthopedic or spine-surgery consultation should be obtained as early as possible.

During exposure and temperature control, a complete examination of the body should be accompanied by active warming measures to maintain a core temperature $> 35^{\circ}\text{C}$. Appropriate measures include the use of warming blankets and warmed intravenous fluids.

Secondary assessment and imaging

Clinical question 2: When should whole-body computed tomography (CT) be used after initial resuscitation in patients with suspected severe injuries involving multiple anatomical regions?

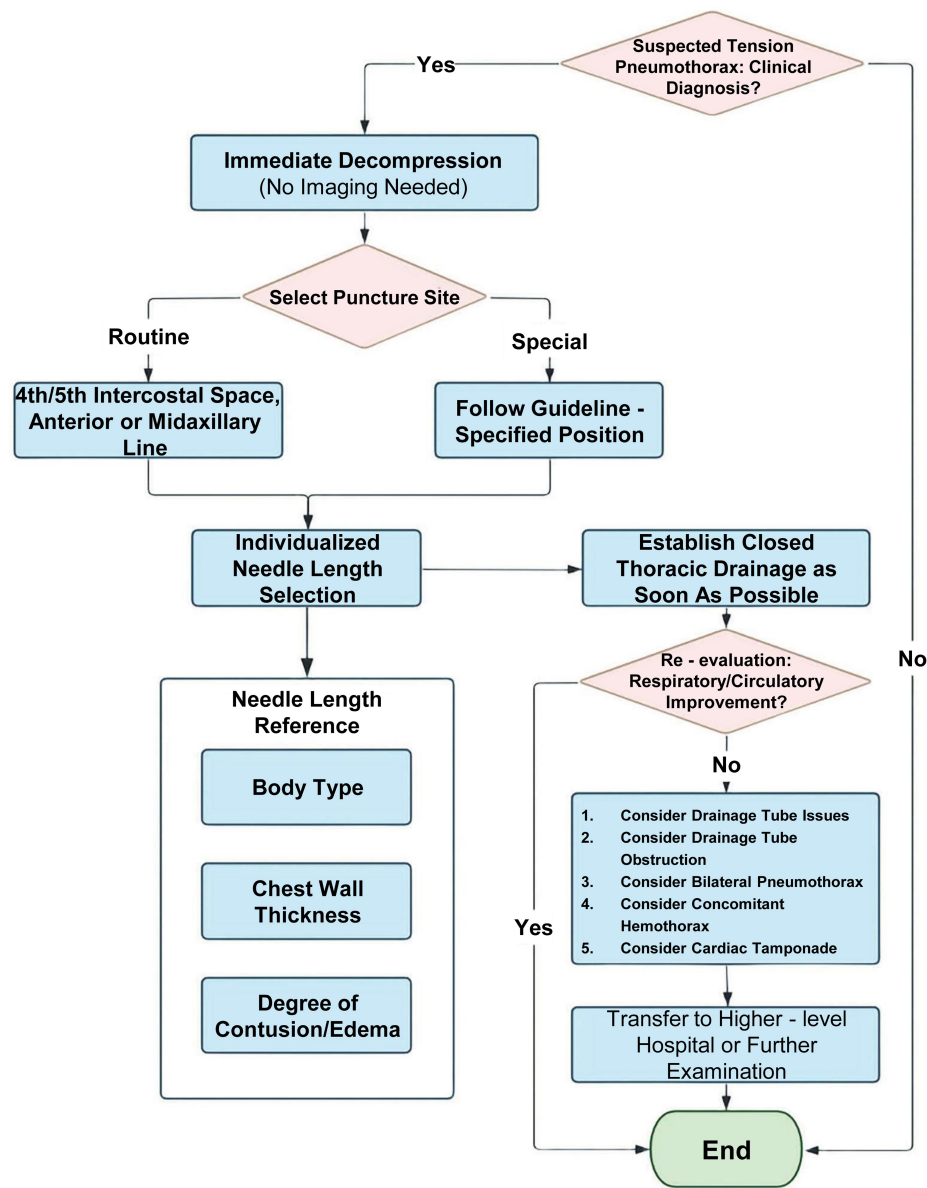


Fig. 3. Emergency management algorithm for tension pneumothorax.

Recommendation 2: In patients with suspected severe injuries involving multiple anatomical regions who have reached criteria for safe transport after initial resuscitation, whole-body CT is suggested as the preferred imaging strategy at institutions where it is available, to improve the efficiency of the initial assessment and reduce missed injuries and repeated transfers. In patients with hemodynamic instability or in resource-limited settings, a staged strategy using extended focused assessment with sonography for trauma (E-FAST) and CT of selected critical anatomical regions should be adopted.
Strength of recommendation: II, weak recommendation

Quality of evidence: B, moderate

Clinical question 3: How should integrated whole-body CT be prioritized relative to immediate hemorrhage control or decompression?

Recommendation 3: In patients with worsening impairment of consciousness, including a decrease in GCS score of ≥ 2 points, an unreliable physical examination, or a high-energy injury mechanism, and whose vital signs meet criteria for safe transport, integrated whole-body CT comprising noncontrast

Table 4. Glasgow Coma Scale

Component	Response	Score
Eye opening (E)	Spontaneous	4
Eye opening (E)	To verbal command	3
Eye opening (E)	To pain	2
Eye opening (E)	No eye opening	1
Verbal response (V)	Oriented to person, time, and place	5
Verbal response (V)	Confused conversation and disorientation	4
Verbal response (V)	Inappropriate but recognizable words	3
Verbal response (V)	Incomprehensible sounds	2
Verbal response (V)	No verbal response	1
Motor response (M)	Obeys commands	6
Motor response (M)	Localizes painful stimulus	5
Motor response (M)	Withdraws from painful stimulus	4
Motor response (M)	Abnormal flexion to pain, or decorticate posturing	3
Motor response (M)	Abnormal extension to pain, or decerebrate posturing	2
Motor response (M)	No motor response to pain	1

The total Glasgow Coma Scale score is the sum of the E, V, and M component scores and ranges from 3 to 15. TBI may be classified into 3 severity categories: a total score of 13–15 indicates mild TBI, 9–12 indicates moderate TBI, and 3–8 indicates severe TBI. TBI, traumatic brain injury.

head CT and contrast-enhanced thoracic and abdominal CT is recommended as the preferred strategy to reduce the risk of missed injuries. When ongoing hemorrhage or an otherwise irreversible life-threatening injury requires immediate hemorrhage control or decompression, the principle of “life-saving intervention before imaging” should be followed. During resuscitation and damage-control management, focused ultrasonography or CT of critical anatomical regions may be used to guide decision-making, with completion of whole-body CT after stabilization.

Strength of recommendation: III, guideline-specific operational conditional strong recommendation
Quality of evidence: B, moderate

Secondary assessment should proceed immediately after life-threatening conditions have been addressed, with particular attention to the appropriate sequencing of E-FAST and other imaging modalities. E-FAST can rapidly identify free air or fluid in the thoracic cavity, pericardial effusion, and free intraperitoneal fluid and is of first-line value in patients with hemodynamic instability or transport limitations. A positive E-FAST finding is highly informative; however, a negative examination does not exclude solid-organ injury within the abdomen. Hemodynamically stable patients should therefore still undergo whole-body CT to reduce the risk of missed injuries.

In patients who are hemodynamically stable or temporarily stabilized after resuscitation, whole-body CT should be the preferred imaging examination. This generally includes head CT with or without intracranial vascular imaging; CT angiography of the cervical arteries and veins when neurological deficits or the

injury mechanism indicate a risk of vascular injury; and contrast-enhanced CT of the thorax, abdomen, and pelvis, with multiphase dynamic acquisition when required to identify active bleeding.²⁵ This approach permits the identification of injuries involving multiple anatomical regions during a single examination and informs the sequencing of surgical interventions.²⁶

The American College of Surgeons Trauma Quality Improvement Program Imaging Best Practices Guidelines and contemporary evidence support protocolized whole-body CT in appropriately selected, transport-safe patients with polytrauma. Centers with appropriate resources should establish standardized whole-body CT protocols and rapid-access CT pathways without delaying immediately required life-saving interventions.²⁷⁻³⁰

Patients with abdominal trauma should be stratified according to the injury mechanism, physical findings, E-FAST findings, and laboratory results. In hemodynamically stable patients with suspected intra-abdominal injury, contrast-enhanced multidetector CT is recommended to improve diagnostic accuracy and guide nonoperative, interventional, or surgical management. A normal physical examination alone cannot reliably exclude intra-abdominal injury, particularly in patients with impaired consciousness or a high-energy injury mechanism.

In hemodynamically unstable patients who require immediate resuscitation, hemorrhage control, or surgical intervention, whole-body CT should be bypassed in favor of immediate life-saving interventions.^{31,32} Interventions may include tube thoracostomy, REBOA, exploratory laparotomy, pelvic arterial embolization, or preperitoneal packing, as clinically appropriate. In selected patients with circulatory shock who can be safely transported and managed with immediate access to resuscitation and intervention, whole-body CT may still be considered.³³ Targeted imaging

assessment may be performed after initial control of hemorrhage and successful resuscitation.^{34,35}

In the management of pelvic injury, application of a pelvic binder before imaging is a widely accepted strategy. This approach may reduce pelvic volume, improve local compression and hemostasis at an early stage, and provide additional time for subsequent interventional or surgical treatment.

Laboratory evaluation

Clinical question 4: Should lactate and base excess be measured serially to identify occult hypoperfusion and monitor resuscitation?

Recommendation 4: Metabolic indices, including lactate and base excess, should be incorporated into the routine initial laboratory assessment at hospital admission and monitored serially in patients with polytrauma to facilitate the early identification of occult hypoperfusion or shock. These metabolic indices should not replace clinical assessment or imaging findings.

Strength of recommendation: II, weak recommendation

Quality of evidence: C, low

Laboratory examinations performed immediately after hospital admission should include arterial blood gas analysis and lactate measurement, coagulation tests, and indices related to organ perfusion, including hemoglobin, platelet count, fibrinogen, prothrombin time or activated partial thromboplastin time, and creatinine. When available, thromboelastography or rotational thromboelastometry (ROTEM) may be added to support goal-directed hemostatic management.

Elevated lactate and an increasingly negative base excess are associated with increased risks of early mortality, transfusion requirements, and complications. Combined interpretation of these indices and their temporal trends provides a more accurate indication of hypoperfusion and the adequacy of resuscitation than a single measurement.³⁶⁻³⁹

A lactate concentration ≥ 2.0 mmol/L may indicate potential hypoperfusion, whereas a lactate concentration ≥ 4.0 mmol/L is highly suggestive of hypoperfusion.^{40,41} A base excess ≤ -6 mmol/L indicates moderate-to-severe acidosis or blood loss and may be used as a warning threshold for severe injury and inadequate resuscitation.^{42,43} These thresholds are influenced by the route and timing of blood sampling, ventilation status, and hepatic function. Serial reassessment and comprehensive clinical interpretation are therefore required.

In patients receiving long-term oral antiplatelet therapy, the risk of bleeding should be assessed in conjunction with the medication history. Bleeding risk should not be ruled out solely on the basis of conventional coagulation test results.

Resuscitation strategies for head, thoracic, abdominal, and pelvic polytrauma

Damage control resuscitation

Clinical question 5: What blood-component ratio should be used

after activation of a massive transfusion protocol?

Recommendation 5: In patients with trauma for whom a massive transfusion protocol has been activated, a balanced transfusion strategy using plasma, platelets, and red blood cells in a ratio of 1:1:1, or an approximate ratio such as 1:1:2, is recommended to support early hemostasis and reduce the risk of hemorrhage-related death within 24 h. Correction of hypothermia, acidosis, and hypocalcemia, timely fibrinogen supplementation, and restrictive fluid resuscitation should be implemented concurrently as core components of the massive transfusion protocol.

Strength of recommendation: I, strong recommendation

Quality of evidence: B, moderate

Clinical question 6: What fibrinogen threshold and target should guide early replacement during severe traumatic hemorrhage?

Recommendation 6: In patients with severe trauma and massive hemorrhage, fibrinogen levels should be monitored and hypofibrinogenemia corrected as early as possible. Fibrinogen should be maintained at a minimum level of 1.5–2.0 g/L. When the fibrinogen level is <1.5 g/L, fibrinogen should be supplemented immediately using either fibrinogen concentrate or cryoprecipitate, with the aim of rapidly restoring the level to 1.5–2.0 g/L. In patients with a fibrinogen level of 1.5–2.0 g/L who have ongoing active hemorrhage or risk factors for massive bleeding, earlier intervention may be considered on the basis of the overall coagulation status. Prothrombin complex concentrate should not generally be included as a routine component of a massive transfusion protocol but may be considered in patients receiving oral anticoagulants or those with a confirmed coagulation-factor deficiency when timely correction with fresh frozen plasma cannot be achieved.

Strength of recommendation: I, strong recommendation

Quality of evidence: B, moderate

Clinical question 7: Which patients should receive tranexamic acid, and within what time window after injury?

Recommendation 7: In patients with trauma or polytrauma and suspected or confirmed bleeding, tranexamic acid should be administered as early as possible and within 3 h after injury to reduce all-cause mortality and hemorrhage-related mortality. Initiation of tranexamic acid treatment more than 3 h after injury is not recommended. In patients with concomitant TBI, the benefit of administration within 3 h after injury is more evident in those with mild-to-moderate TBI. The benefit remains uncertain in patients with severe TBI, defined as a GCS score of 3–5, or when more than 3 h have elapsed since injury, and individualized assessment is

therefore required.

Strength of recommendation: I, strong recommendation

Quality of evidence: A, high

Damage control resuscitation requires the early implementation of comprehensive measures, including balanced component transfusion, coagulation management guided by thromboelastography or rotational thromboelastometry, antifibrinolytic therapy, correction of the triad of hypothermia, acidosis, and coagulopathy, and hemorrhage control. In patients with active massive hemorrhage for whom immediate thromboelastography- or rotational thromboelastometry-guided management is unavailable, an empirical resuscitation strategy using plasma, platelets, and red blood cells in a ratio of 1:1:1, or an approximate ratio such as 1:1:2, is suggested. This strategy may reduce the risk of hemorrhage-related death within 24 h.⁴³⁻⁴⁸ During implementation of a massive transfusion protocol, active correction of hypothermia, acidosis, and hypocalcemia and the use of restrictive fluid resuscitation should be undertaken concurrently as core components of care.

Fibrinogen is a key determinant of trauma-induced coagulopathy. Fibrinogen levels should be maintained at 1.5–2.0 g/L. When the fibrinogen level is <1.5 g/L, supplementation should be initiated immediately using fibrinogen concentrate or cryoprecipitate to increase the level to ≥ 1.5 g/L as rapidly as possible.⁴⁹⁻⁵² Selection of the specific product should be based on availability, speed of onset, and potential risks, including infection and volume overload.

Common initial doses include 2–4 g of fibrinogen concentrate, 25–50 mg/kg, or 4–6 units of cryoprecipitate. Subsequent dosing should be adjusted according to the maximum clot firmness measured using FIBTEM, a dedicated ROTEM assay, or repeat fibrinogen measurements. In patients with fibrinogen levels of 1.5–2.0 g/L who have ongoing active hemorrhage or are at high risk of continued bleeding, increased vigilance and earlier intervention should be considered. Prothrombin complex concentrate is not a routine component of massive transfusion protocols. Its use is primarily reserved for patients receiving oral anticoagulants or those with a specific coagulation-factor deficiency when fresh frozen plasma cannot provide sufficiently rapid correction. A comprehensive assessment is required before administration.

Patients with suspected or confirmed traumatic hemorrhage should receive tranexamic acid as soon as possible, within 3 h after injury and preferably within 1 h. The recommended regimen is an intravenous loading dose of 1 g administered over at least 10 min. When resources are limited, the dose should be administered by a controlled, slow intravenous infusion or injection to avoid hemodynamic instability caused by rapid administration, followed by a further 1 g infused over 8 h. This regimen may reduce all-cause mortality and hemorrhage-related mortality.^{53,54} Large randomized trials, pooled analyses, and observational studies, including the Clinical Randomisation of an Antifibrinolytic in Significant Haemorrhage trials CRASH-2 and CRASH-3, did not demonstrate a significant increase in the overall risk of thrombotic or vascular occlusive events with tranexamic acid.⁵⁵⁻⁶¹ A mechanistic CRASH-3 substudy was designed to examine the effects of tranexamic acid on intracranial hemorrhage and cerebral

ischemia.⁶²

Initiating tranexamic acid more than 3 h after injury may provide no benefit. In patients with TBI, treatment within 3 h provides a clear benefit in mild-to-moderate TBI. In patients with severe TBI, defined as a GCS score of 3–5, or in those treated more than 3 h after injury, the benefit remains uncertain, and treatment decisions should be individualized. The timing of tranexamic acid administration and its integration with damage control resuscitation are shown in Figure 4.

In the prehospital setting or when evacuation is restricted, resuscitation should aim to maintain perfusion of vital organs while preventing resuscitation-associated rebleeding. Crystalloid administration should be restricted, blood components or whole blood should be prioritized, and hemorrhage control should be achieved as soon as possible.

In patients with hemorrhagic shock without TBI, permissive hypotension may be considered after adequate assessment as a short-term bridging strategy before hemorrhage is controlled. In patients with confirmed or suspected TBI, prevention of hypoperfusion should be prioritized. During hemorrhage-control procedures or neurosurgical intervention, an SBP of ≥ 110 mmHg or MAP of ≥ 80 mmHg is suggested.^{13,63-65} When ICP can be monitored, CPP should be maintained at ≥ 60 mmHg.^{13,65,66} Synthetic colloids, including hydroxyethyl starch, should be avoided during resuscitation.^{67,68}

Blood pressure and perfusion targets

Clinical question 8: How should blood-pressure targets be stratified according to the presence or absence of severe TBI?

Recommendation 8: In patients with hemorrhagic shock without TBI or spinal cord injury, permissive hypotension or restrictive resuscitation may be used before a definitive hemorrhage-control pathway has been established, with an SBP target of 80–90 mmHg to reduce the risks of rebleeding and dilutional coagulopathy. In patients with concomitant severe TBI, defined as a GCS score of ≤ 8 , permissive hypotension is not recommended. Hypoperfusion should be avoided both before and after hemorrhage control, and MAP should be maintained at ≥ 80 mmHg whenever possible. When continuous MAP or ICP monitoring is unavailable, an SBP of ≥ 110 mmHg or MAP of ≥ 80 mmHg may be used as a bedside target. These are guideline-specific conservative operational targets for patients with polytrauma. When ICP monitoring is available, treatment should be individualized to achieve a CPP of 60–70 mmHg. These values represent minimum safety thresholds during the period of uncontrolled hemorrhage and are not equivalent to the cerebral-protection targets applied after hemorrhage has been controlled.

Strength of recommendation: II, weak recommendation

Quality of evidence: D, very low

Blood pressure and perfusion management should be individualized. In patients with hemorrhagic shock without concomitant severe TBI, restrictive volume resuscitation and permissive hypotension are recommended. Before definitive hemostasis is achieved, SBP should be maintained at 80–90 mmHg to reduce the risks of rebleeding and dilutional coagulopathy.⁶⁹⁻⁷¹ If hypo-

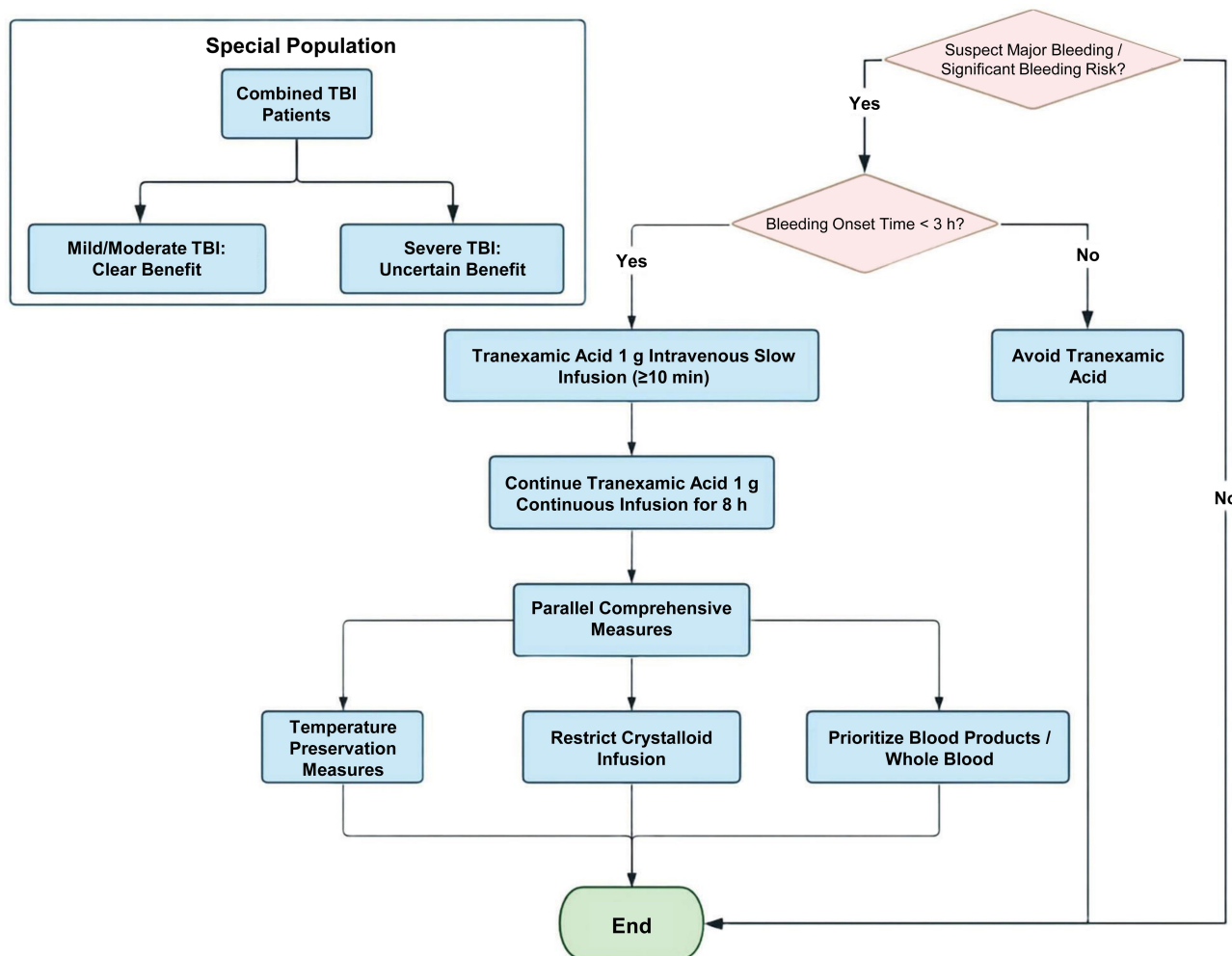


Fig. 4. Timing of tranexamic acid administration and its integration with damage control resuscitation during the early hemostatic window. TBI, traumatic brain injury.

tension persists after hemostatic resuscitation, vasopressor therapy should be individualized because comparative outcome evidence remains limited.^{72,73}

This strategy is not applicable to patients with concomitant severe TBI, defined as a GCS score of ≤ 8 . The Brain Trauma Foundation (BTF) suggests maintaining SBP at ≥ 100 mmHg in patients aged 50–69 years and at ≥ 110 mmHg in patients aged 15–49 years or >70 years.¹³ In this guideline, an SBP of ≥ 110 mmHg is adopted as a conservative operational target for patients with severe TBI and polytrauma. Isotonic crystalloid solutions should be used preferentially for resuscitation, excessive administration should be avoided, and blood products should be prioritized to reduce the risk of cerebral edema.⁷⁴

In patients with concomitant severe lung injury, circulatory and ventilatory requirements must be balanced. A low-tidal-volume ventilation strategy with an appropriate level of positive end-expiratory pressure should be used to improve oxygenation. Excessively high positive end-expiratory pressure may adversely affect hemodynamics; therefore, blood pressure, lactate, and other relevant parameters should be monitored dynamically.^{75,76}

In patients with severe TBI and evidence of structural brain injury, ICP monitoring is suggested when appropriate resources are available, with a treatment target of ICP < 22 mmHg.^{13,14} When both MAP and ICP can be monitored, CPP should be maintained at 60–70 mmHg.^{13,65} Before an invasive procedure, the risks should be carefully evaluated and discussed with the patient's family, and coagulation abnormalities should be corrected whenever possible. Monitoring must remain continuous during patient transport.^{13,14}

Fluid resuscitation in patients with severe thoracic injury

Clinical question 9: What intensity of fluid and blood-product resuscitation should be used before definitive hemorrhage control?

Recommendation 9: Excessively aggressive fluid resuscitation is associated with increased risks of acute lung injury, acute respiratory distress syndrome, and adverse outcomes. Restrictive fluid resuscitation combined with rapid definitive hemorrhage control and balanced blood-component

resuscitation using a plasma-to-platelets-to-red blood cells ratio of 1:1:1 or 1:1:2 may reduce resuscitation-related complications. Large volumes of crystalloids or blood products should not be administered indiscriminately before hemorrhage has been controlled. Resuscitation should aim to maintain the minimum perfusion necessary while hemorrhage control and correction of coagulopathy are pursued concurrently.

Strength of recommendation: II, weak recommendation

Quality of evidence: D, very low

Thoracic injury is a major determinant of mortality in patients with polytrauma. In patients with massive hemothorax, defined as an initial drainage volume of ≥ 1500 mL or an output of >200 mL/h persisting for 3 h, tension pneumothorax, or progressive respiratory failure accompanied by imaging evidence, tube thoracostomy should be performed immediately.^{21,22,77}

When in-hospital cardiac arrest occurs and a reversible intrathoracic cause, such as cardiac tamponade or cardiac or great-vessel injury, is strongly suspected, emergency thoracotomy may be considered after rapid assessment according to established indications. Applicable emergency-consent requirements should be followed without delaying life-saving treatment. In patients with blunt trauma, careful assessment is required to avoid futile resuscitative procedures.

Fluid resuscitation must be coordinated with the respiratory-support objectives required for thoracic injury. Evidence indicates that excessive crystalloid administration during the early period after hospital admission is associated with the development of acute lung injury or acute respiratory distress syndrome and with adverse outcomes.^{78,79}

In patients with massive hemorrhage, balanced blood-component resuscitation using a plasma-to-platelets-to-red blood cells ratio of 1:1:1 or 1:1:2 should be prioritized over crystalloid-dominant resuscitation.^{43,44,79} Potential differences in outcomes and treatment response according to blunt versus penetrating injury mechanism have also been explored.⁸⁰ Randomized controlled trials in acute respiratory distress syndrome also provide a physiological basis for restrictive fluid management after trauma.⁸¹⁻⁸³

Major trauma guidelines emphasize restricting crystalloid administration, prioritizing balanced blood-component resuscitation, and achieving definitive hemorrhage control and goal-directed correction of coagulation abnormalities as rapidly as possible.^{42,79,84,85} A systematic review identified the amount of crystalloid resuscitation as a potentially modifiable factor associated with post-traumatic acute respiratory distress syndrome.⁸⁶

Hemorrhage-control strategies in patients with severe abdominal or pelvic injury

Clinical question 10: What is the appropriate role of REBOA?

Recommendation 10: Routine use of REBOA is not recommended. It may be used only in patients in an extremely

critical condition when, after multidisciplinary assessment and full communication with the patient's family, surgical or interventional hemorrhage control cannot be provided in a timely manner and circulation cannot be maintained despite full implementation of all fundamental measures, including a massive transfusion protocol, tranexamic acid treatment, and pelvic stabilization. In such circumstances, an experienced team may use REBOA as a strictly controlled and time-limited bridging intervention while definitive hemorrhage control is prepared immediately. Complications must be monitored throughout the procedure, and relevant quality indicators must be documented.

Strength of recommendation: III, guideline-specific operational conditional strong recommendation

Quality of evidence: D, very low

Rationale for recommendation strength: The evidence is very uncertain, and the procedure carries important vascular and ischemic risks. The guideline-specific category III designation is therefore limited to an exceptional, time-limited bridge when fundamental resuscitative measures have failed, definitive hemorrhage control is being prepared, and an experienced team is available.

In patients with hemodynamic instability and suspected intra-abdominal hemorrhage, damage-control principles should be followed, and life-saving surgery, including exploratory laparotomy, should be prioritized.^{31,43}

Resuscitative endovascular balloon occlusion of the aorta may be used as a temporary bridging intervention for noncompressible massive hemorrhage arising from selected anatomical regions, particularly the lower torso or pelvis, when adequate resuscitation has failed. However, a survival benefit from routine use remains uncertain, and the procedure carries potential risks.⁸⁷⁻⁹¹ Indications must therefore be strictly controlled, occlusion time minimized, and the procedure performed by a systematically trained team.

Resuscitative endovascular balloon occlusion of the aorta is classified according to the location of balloon occlusion within aortic zones I to III. Zones I and III are most commonly used in clinical practice. Zone I extends from the region near the diaphragm to a point above the origin of the renal arteries and is used to control hemorrhage arising from the thoracoabdominal junction and upper abdomen. Zone III extends from below the renal arteries to above the aortic bifurcation and is primarily used to control pelvic hemorrhage.

Zone I occlusion causes extensive ischemia of the abdominal viscera. Continuous occlusion should generally not exceed 30 minutes, and definitive hemorrhage control and balloon deflation should be completed within this period.⁸⁹

In patients with pelvic injury, definitive hemorrhage control, including interventional embolization, should be undertaken as rapidly as possible after early placement of a pelvic binder. When severe blood loss, physiological derangement, or another severe injury such as TBI is present, a damage-control surgical strategy should be adopted. Hemorrhage and contamination should first be controlled rapidly, after which the patient should be transferred to the intensive care unit (ICU) for resuscitation and correction of

physiological abnormalities. Definitive surgery should then be undertaken as a staged procedure, avoiding complex operations while the patient remains at the limit of physiological tolerance.

Resuscitation in patients with concomitant severe TBI

Clinical question 11: How should torso hemorrhage and intracranial hypertension be managed when both are immediately life threatening?

Recommendation 11: When refractory torso hemorrhage or hemorrhagic shock coexists with intracranial hypertension, definitive hemorrhage control should be prioritized to save the patient's life, and cranial decompression should be performed as rapidly as possible. At centers with the required resources, parallel hemorrhage-control and neurosurgical procedures are recommended. When signs of cerebral herniation are present, rapid burr-hole decompression or external ventricular drainage may be performed as a bridging decompressive measure to gain time, provided that life support is maintained. Definitive hemorrhage control or parallel surgery should then be undertaken immediately.

Strength of recommendation: III, guideline-specific operational conditional strong recommendation

Quality of evidence: D, very low

Rationale for recommendation strength: Direct evidence is very uncertain, but delayed control of fatal torso hemorrhage or delayed treatment of impending cerebral herniation can each cause irreversible harm. The operational recommendation therefore emphasizes explicit prerequisites, parallel teams when feasible, rapid reassessment, and individualized sequencing rather than routine use of a single fixed order.

When these coexisting life-threatening injuries are managed, the central objectives are to control hemorrhage rapidly to reverse shock and to minimize the duration of brain-tissue compression. At centers with a hybrid operating room, the patient should preferentially be transferred directly to the hybrid operating room to permit hemorrhage-control and decompressive procedures to be performed in parallel or in rapid sequence.^{74,92-96}

The first objective is rapid achievement of definitive hemorrhage control through surgical or interventional treatment. Once preliminary hemodynamic stabilization has been achieved, definitive intracranial decompression should be performed immediately or concurrently. Given the very low quality of the comparative evidence, this sequence represents expert consensus informed by damage-control principles and multidisciplinary case experience.^{84,93-96}

Physiological management must focus on preventing hypoxemia and hypotension. In patients with concomitant severe TBI, the primary objective of ventilation is to ensure adequate oxygenation, with PaCO₂ maintained at 35–40 mmHg. Brief hyperventilation may be used only as an emergency rescue measure in the presence of acute cerebral herniation.

Isotonic crystalloid solutions should be used preferentially for fluid resuscitation, and goal-directed transfusion therapy should be initiated as early as possible.^{43-45,79} When mannitol or hypertonic saline is administered for osmotherapy, blood pressure must be

monitored and maintained concurrently to prevent secondary hypotension.⁹⁷

On the basis of evidence from the CRASH studies and related research, routine administration of high-dose glucocorticoids for neuroprotection or reduction of ICP in patients with TBI is not recommended.^{13,98} Glucocorticoids may be considered under specialist supervision only when there is clear evidence of adrenocortical insufficiency or when refractory shock persists despite adequate resuscitation and vasopressor therapy. Associated risks must be closely monitored.

Perioperative management of head, thoracic, abdominal, and pelvic polytrauma

Deep vein thrombosis prophylaxis

Clinical question 12: When should pharmacological prophylaxis for venous thromboembolism be initiated after polytrauma with TBI?

Recommendation 12: Provided that hemorrhage has been controlled and imaging of critical anatomical regions, such as head CT, is stable, eligible patients should receive pharmacological prophylaxis as early as possible after multidisciplinary assessment to reduce the risk of deep vein thrombosis. The timing of initiation, specific regimen, and intensity of anticoagulation should be individualized according to the balance between bleeding and thrombotic risks.

Strength of recommendation: II, weak recommendation

Quality of evidence: C, low

Patients with polytrauma who are at high risk of deep vein thrombosis should undergo early risk assessment and receive mechanical prophylaxis. Pharmacological prophylaxis should be added as soon as the risk of bleeding has been adequately controlled. In patients with TBI and stable repeat imaging and neurological findings, low-molecular-weight heparin together with mechanical prophylaxis may be initiated within 24–72 h after injury, with timing individualized according to the risk of hemorrhage progression.⁹⁹ The timing of initiation should be determined by comprehensively assessing the risks of intracranial, intrathoracic, intra-abdominal, and pelvic bleeding and the findings of repeat imaging. The decision should be fully discussed with the patient's family and documented.

Prophylactic placement of an inferior vena cava filter is not routinely recommended. Enoxaparin is a commonly used first-line agent, and the dose may be adjusted according to anti-factor Xa activity. When the risk of bleeding is high, intermittent pneumatic compression may be used as a bridging measure, with reassessment within 24–72 h.⁹⁹⁻¹⁰⁹

In patients with severe TBI, low-molecular-weight heparin may be considered after head CT findings have remained stable for 24–72 h. This decision should be made jointly with the neurosurgical team, with ongoing assessment of the risk of recurrent bleeding.¹⁰⁰⁻¹⁰⁹ A common initial regimen is enoxaparin 30 mg administered subcutaneously every 12 h. The dose should be adjusted according to body weight, renal function, and anti-factor

Xa activity. Unfractionated heparin may be considered in patients with renal impairment. The pathway for initiating and reassessing deep vein thrombosis prophylaxis is shown in [Figure 5](#).

Seizure prophylaxis

Clinical question 13: Which patients should receive antiseizure prophylaxis after severe TBI, and for how long?

Recommendation 13: Patients with concomitant severe TBI should receive prophylactic antiseizure treatment for 7 days. Treatment beyond 7 days is not recommended. Levetiracetam or phenytoin/fosphenytoin may be used. Lacosamide may be considered as an alternative when these agents are unsuitable, although the supporting evidence is limited to observational data. Selection should be individualized based on adverse effects, drug interactions, availability, and patient comorbidities. In patients who were already receiving long-term treatment with a specific antiseizure medication, such as sodium valproate, because of pre-existing epilepsy, continuation or adjustment of the regimen may be considered after neurological specialist assessment.

Strength of recommendation: I, strong recommendation

Quality of evidence: B, moderate

Patients with severe TBI are at risk of early post-traumatic seizures. The fourth edition of the BTF guidelines indicates that short-term prophylaxis during the first 7 days reduces the incidence of early seizures occurring within 7 days but does not reduce the risk of late seizures occurring after 7 days.¹³ Prophylaxis should therefore not be continued beyond 7 days.¹¹⁰⁻¹¹³

Available evidence suggests that levetiracetam and phenytoin have generally comparable efficacy in preventing early post-traumatic seizures. Levetiracetam has fewer drug interactions and requires less complex monitoring and may therefore be selected as a commonly preferred agent.^{114,115}

Patients with high-risk features, including cortical contusion or laceration, intracranial hematoma, penetrating injury, or alcohol withdrawal, may be considered for continuous or prolonged electroencephalographic monitoring to identify and promptly manage nonconvulsive seizures.¹¹⁶ Limited retrospective evidence suggests that lacosamide may have similar efficacy to phenytoin for early post-traumatic seizure prophylaxis and may be associated with fewer adverse drug events, although prospective validation is required.¹¹⁷ The selection of antiseizure medications and the time point for discontinuation within the 7-day early post-traumatic seizure prevention strategy are summarized in [Figure 6](#).^{110-115,117,118}

Early rehabilitation

Clinical question 14: When should early rehabilitation begin after head, thoracic, abdominal, and pelvic polytrauma?

Recommendation 14: Early rehabilitation should be initiated within 48 h after injury, provided that intracranial imaging

findings and vital signs are stable.

Strength of recommendation: II, weak recommendation

Quality of evidence: C, low

The objectives of postoperative and ICU rehabilitation in patients with polytrauma are to promote functional recovery, reduce disability, and support independence.¹¹⁹ A multidisciplinary team comprising trauma surgeons, orthopedic surgeons, neurosurgeons, critical care physicians, rehabilitation specialists, respiratory specialists, nutritionists, and nursing staff should implement a staged and goal-directed rehabilitation pathway.¹¹⁹

A Cochrane review and a retrospective pre-post study in trauma patients admitted to the ICU suggest that multidisciplinary rehabilitation and standardized early mobilization may improve functional and mobility outcomes^{120,121}; the latter study also reported a shorter ICU stay. Studies in patients with TBI and other neurocritical conditions further suggest that phased or progressive early mobilization may improve mobility-related outcomes and may shorten ICU stay or the duration of mechanical ventilation in selected patients when implemented with appropriate monitoring.¹²²⁻¹²⁴

Surgical strategies for head, thoracic, abdominal, and pelvic polytrauma

To standardize the indications and timing of surgical intervention, the indications and trigger criteria for surgery or interventional treatment across different organ systems are summarized in [Table 5](#).

Prioritization of surgical interventions

Clinical question 15: How should hemorrhage-control procedures and intracranial surgery be prioritized or coordinated?

Recommendation 15: In the presence of uncontrolled hemorrhage, surgical or interventional control of intrathoracic, intra-abdominal, or pelvic bleeding should be prioritized to restore perfusion and oxygenation. When the circulation is relatively stable but a definite intracranial hypertensive crisis is present, intracranial decompression or hematoma evacuation should be prioritized. At institutions with a hybrid operating room and the capacity for interdisciplinary team collaboration, simultaneous hemorrhage-control and decompressive procedures may be considered.

Strength of recommendation: I, strong recommendation

Quality of evidence: D, very low

Rationale for recommendation strength: The certainty of evidence is very low because randomized comparisons of competing emergency operative sequences are not feasible. The strong recommendation reflects the immediate lethality of uncontrolled hemorrhage, the need to prevent secondary brain injury, the high clinical feasibility of threat-based prioritization, and unanimous expert agreement; the simultaneous-procedure component remains conditional on resources and team capability.

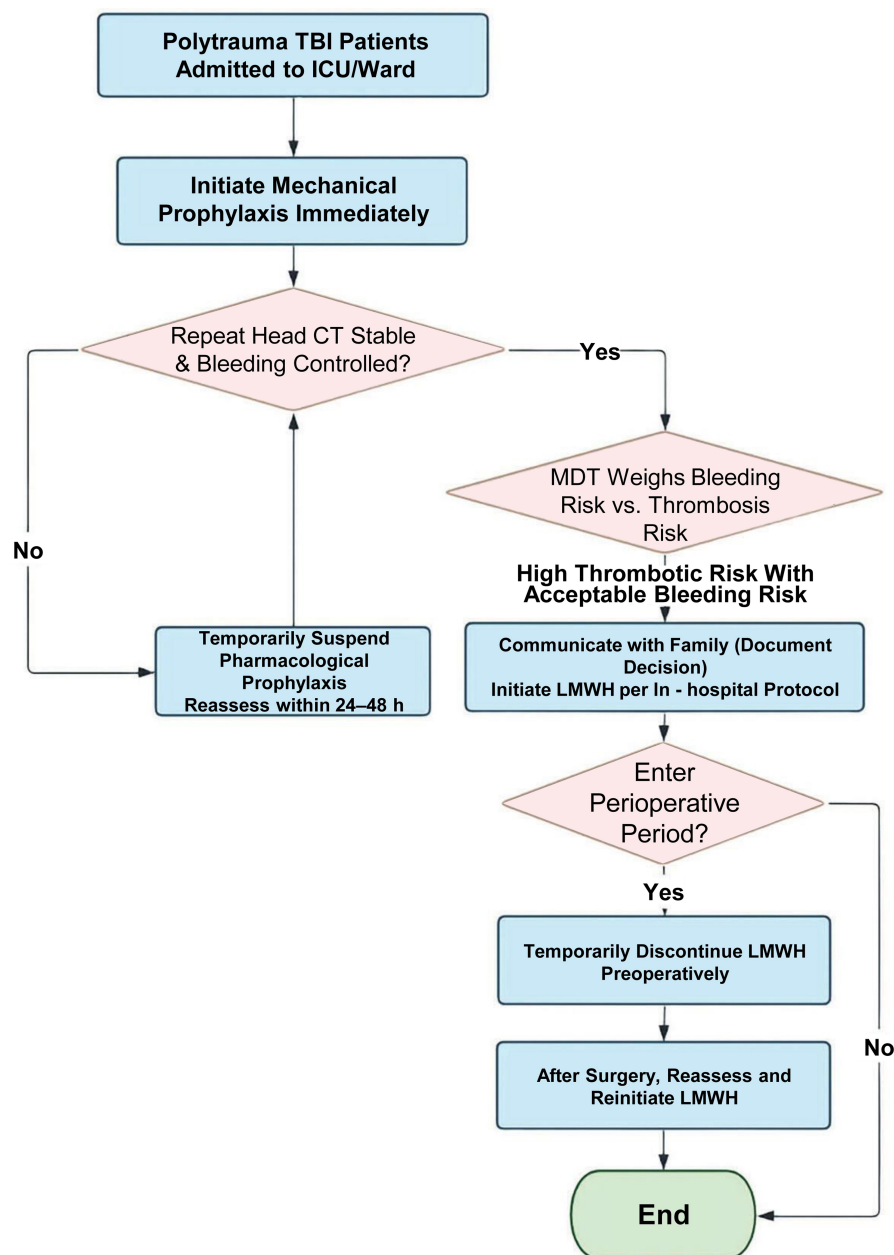


Fig. 5. Dynamic reassessment pathway for deep vein thrombosis prophylaxis. CT, computed tomography; ICU, intensive care unit; LMWH, low-molecular-weight heparin; MDT, multidisciplinary team; TBI, traumatic brain injury.

The central principle governing the sequence of surgical interventions is a dynamic balance between saving the patient's life and protecting the brain. Uncontrolled massive thoracic, abdominal, or pelvic hemorrhage rapidly causes hypoperfusion and coagulopathy and should therefore be controlled first. Conversely, an intracranial crisis manifested by progressive pupillary changes, midline shift, or similar findings indicates a risk of irreversible brain injury and requires decompression as rapidly as possible.

Scenario A: uncontrolled torso hemorrhage. Prioritize surgical or interventional hemorrhage control while maintaining

oxygenation and the minimum cerebral perfusion target.

Scenario B: relatively stable circulation with an intracranial hypertensive crisis. Prioritize hematoma evacuation or decompression, with concurrent preparation for torso intervention.

Scenario C: both threats are immediately life-threatening. Use parallel teams in a hybrid operating environment when available; otherwise, perform the shortest effective bridging procedure for the more immediately reversible threat and reassess without delay.

Scenario D: limited institutional resources. Use staged

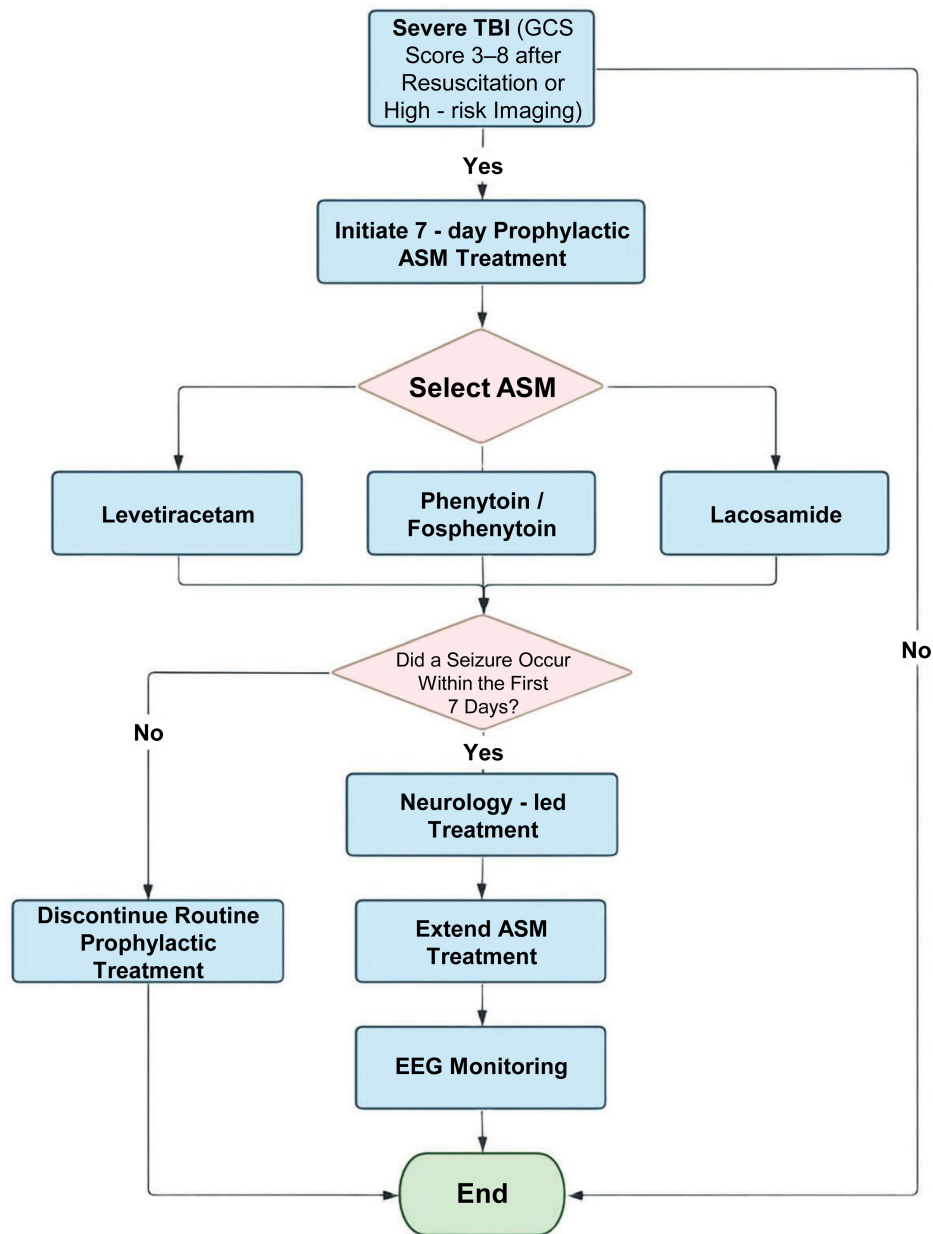


Fig. 6. Seven-day strategy for the prevention of early post-traumatic seizures. ASM, antiseizure medication; GCS, Glasgow Coma Scale; TBI, traumatic brain injury; EEG, electroencephalogram.

damage-control treatment, activate early transfer, and avoid complex parallel procedures that cannot be supported safely.

When a hybrid operating room and multidisciplinary team are available, simultaneous surgery may be considered to shorten the interval from diagnosis to completion of definitive hemorrhage control and intracranial decompression.⁷⁴ The following points should be considered during implementation:

(1) **Unified command and predefined planning:** Before incision, the anesthesiology or trauma team leader should coordinate the participating teams and rapidly define the priority between hemorrhage control and decompression, the critical physiological thresholds, including SBP, MAP, ICP,

CPP, and PaCO₂ targets, and the circumstances under which another team's operative procedure should be suspended.

(2) **Positioning and operative-field management:** A position that accommodates both craniotomy and transfemoral interventional or open abdominal surgery should be selected whenever possible. If intraoperative repositioning is required, it should be performed only after reliable intracranial hemostasis has been confirmed, the wound has been appropriately covered, and head fixation and all tubes and lines have been secured.

(3) **Monitoring calibration:** Following every substantial change in patient position or operating-table height, the arterial

Table 5. Indications and trigger criteria for surgical or interventional treatment across organ systems in patients with polytrauma

Organ system	Injury or clinical situation	Trigger criteria: the presence of any criterion may warrant surgical or interventional treatment	Principal basis
Craniocerebral	Progressive mass effect or risk of cerebral herniation, including hematoma and diffuse cerebral swelling	Progressive neurological deterioration or the development or progression of signs of cerebral herniation; or imaging evidence of a substantial mass effect inconsistent with the clinical presentation	BTF severe TBI guideline, including threshold and management frameworks ^{13,14}
Craniocerebral	Refractory intracranial hypertension requiring escalation of treatment or consideration of decompression	Persistent ICP >22 mmHg despite stepwise medical management; persistent ICP ≥25 mmHg more closely represents the population with genuinely refractory, life-threatening intracranial hypertension	BTF threshold recommendations and the enrollment threshold used in RESCUEicp ^{13,14}
Thoracic	Tension pneumothorax	A clinical diagnosis is sufficient when severe respiratory or circulatory compromise or progressive hypoxemia or hypotension is present; immediate decompression followed by chest-tube placement is required	ATLS principles for life-threatening thoracic injury and thoracic trauma consensus recommendations ^{17,125,126}
Thoracic	Massive hemothorax or ongoing intrathoracic hemorrhage requiring consideration of thoracotomy or definitive hemostasis	Immediate chest-tube output of 1000–1500 mL; ongoing output >200 mL/h for 2–4 h; or an ongoing transfusion requirement or shock that is difficult to correct	Thoracic trauma guidelines and reviews ^{126–128}
Abdominal	Intra-abdominal hemorrhage with hemodynamic instability	Hemodynamic instability with a poor or transient response to resuscitation, together with a positive E-FAST examination or a high suspicion of intra-abdominal hemorrhage, requiring surgical hemorrhage control or damage-control surgery; interventional hemorrhage control may be considered when appropriate resources are available	WSES liver-trauma recommendations indicating that unstable or nonresponding patients require surgical treatment ^{129,130}
Abdominal	Solid-organ injury in a hemodynamically stable patient	Hemodynamic stability favors nonoperative management; an ongoing transfusion requirement, hemodynamic deterioration, or imaging evidence of active bleeding requires escalation to interventional or surgical treatment	WSES framework for nonoperative and surgical management of liver injury ^{129,130}
Pelvic	Hemorrhagic shock associated with pelvic fracture	Hemodynamic instability with suspected pelvic hemorrhage requires immediate placement of a pelvic binder or external fixation for early stabilization, followed, at appropriately equipped centers, by rapid hemorrhage control using preperitoneal packing or transcatheter arterial embolization	WSES pelvic-trauma recommendations supporting early stabilization and early transcatheter arterial embolization or other rapid treatment in unstable patients ¹³¹

ATLS, Advanced Trauma Life Support; BTF, Brain Trauma Foundation; E-FAST, extended focused assessment with sonography for trauma; ICP, intracranial pressure; RESCUEicp, Randomised Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intracranial Pressure; TBI, traumatic brain injury; WSES, World Society of Emergency Surgery.

Multidisciplinary guidelines emphasize that prioritization of hemorrhage control should not be achieved at the expense of neuroprotection. Hypoxemia and hypotension must be rigorously avoided. When ICP is not monitored, this guideline uses an SBP of ≥ 110 mmHg as a conservative operational minimum.^{13,63,65,66} When ICP monitoring is available, CPP should be maintained at 60–70 mmHg.^{13,65,66}

An observational comparative study and case reports suggest that a hybrid operating-room or dual-team model is feasible and may shorten combined procedural time; however, high-quality evidence demonstrating improvements in mortality or neurological outcomes remains lacking.^{92,94,95}

Craniocerebral surgical strategies

Clinical question 16: When should decompressive craniectomy be considered for refractory intracranial hypertension?

Recommendation 16: In patients with medically refractory, life-threatening intracranial hypertension, such as persistent ICP > 22 mmHg despite intensive medical treatment, decompressive craniectomy should be considered to reduce mortality. The patient's family must be fully informed of the increased risk of severe disability, and routine use in patients with early or nonrefractory intracranial hypertension should be avoided. For an intracranial space-occupying hematoma, hematoma evacuation should be the primary objective. Strength of recommendation: I, strong recommendation. Quality of evidence: B, moderate.

Surgical decisions should integrate imaging findings and neurological assessment, with the objectives of maintaining cerebral perfusion and controlling ICP. Surgical evacuation is recommended for an acute subdural hematoma with a thickness > 10 mm or a midline shift > 5 mm. Even when the GCS score is relatively high at admission, the risk of rapid deterioration should be recognized.¹³²

Nonoperative treatment may be considered only in patients with intact neurological function and concordant clinical and imaging findings who can be closely observed in a setting where immediate surgery is available. Such observation should include frequent neurological assessments and repeat CT at short intervals.

In patients with coma, defined as a GCS score < 9 , surgery should be considered when progressive findings are present, including a decrease in GCS score of ≥ 2 points, pupillary abnormalities, or persistent ICP > 20 mmHg, even when the conventional imaging thresholds have not been reached.¹³² The indications for surgery for acute epidural hematoma should be determined by comprehensively assessing hematoma volume, mass effect, and progressive neurological deterioration.

When a patient develops medically refractory intracranial hypertension, with persistent ICP > 22 mmHg representing one of the major decision thresholds, and intensive medical treatment has failed in the presence of a life-threatening condition, decompressive craniectomy should be carefully evaluated through multidisciplinary discussion. The benefits and harms, specifically reduced mortality but an increased risk of severe disability, should be fully discussed with the patient's family.

Key evidence indicates that, in patients at an earlier stage of diffuse TBI with ICP > 20 mmHg, the DECRA trial found that decompressive craniectomy did not reduce mortality and could increase the risk of an unfavorable outcome.¹³³ In patients with more refractory intracranial hypertension, defined by ICP ≥ 25 mmHg, the RESCUEicp trial demonstrated that decompressive craniectomy substantially reduced mortality but also substantially increased the number of survivors with severe disability.¹³⁴

Persistent ICP > 22 mmHg is therefore recommended as an important threshold for assessing escalation of intervention, while routine decompressive craniectomy at an early stage or at a low ICP threshold should be avoided. The BTF guideline classifies decompressive craniectomy as a Level IIA recommendation for reducing mortality in clearly defined refractory intracranial hypertension and emphasizes the need for individualized assessment and communication.^{13,14}

Randomized trials and guideline syntheses have shown that decompressive craniectomy controls ICP and reduces mortality in selected patients with refractory intracranial hypertension, but it may increase survival with severe disability.^{13,14,133,134} The timing and technique of surgery should be individualized. After surgery, the patient should be transferred to the ICU, and CPP should be maintained at 60–70 mmHg to prevent secondary brain injury.^{13,65,66}

Thoracic surgical strategies

Clinical question 17: How should traumatic hemothorax or ongoing intrathoracic hemorrhage be escalated from drainage to definitive hemostasis?

Recommendation 17: Hemorrhage associated with thoracic trauma should be managed using a stepwise strategy of “tube placement for initial quantification, followed by escalation of hemorrhage control”. The first intervention should be placement of a large-bore chest tube to achieve decompression, drain blood, and quantify bleeding. Hemorrhage control should subsequently be escalated in a timely manner according to drainage thresholds, such as an initial output ≥ 1500 mL or ongoing output ≥ 200 mL/h, and the patient's hemodynamic status. Escalation may include video-assisted thoracoscopic surgery, thoracotomy, or transcatheter arterial embolization. Chest-tube placement alone should not result in active bleeding being overlooked. Multidisciplinary collaboration is required throughout the process to shorten the time to hemorrhage control. Strength of recommendation: I, strong recommendation. Quality of evidence: C, low.

Rationale for recommendation strength: The certainty of evidence is low, but failure to recognize ongoing intrathoracic hemorrhage after tube thoracostomy may delay definitive hemostasis and cause preventable death. The stepwise pathway uses observable drainage and physiological criteria, permits several definitive modalities, and achieved unanimous panel agreement.

Clinical question 18: How should a life-threatening thoracic injury be prioritized when it coexists with TBI?

Recommendation 18: When a life-threatening thoracic injury, such as tension pneumothorax or cardiac tamponade, coexists with TBI, the thoracic emergency must be managed first to restore ventilation and circulation, which are prerequisites for maintaining cerebral perfusion. Life-saving interventions, including thoracic decompression, should be performed immediately, and hypoxemia and hypotension must be rigorously avoided throughout treatment. After hemorrhage has been controlled, blood pressure should be restored as rapidly as possible to the cerebral-protection target: when ICP is not monitored, SBP should be maintained at ≥ 110 mmHg or MAP at ≥ 80 mmHg; when ICP monitoring is available, management should be guided by the CPP target.

Strength of recommendation: I, strong recommendation
Quality of evidence: C, low

Rationale for recommendation strength: The certainty of evidence is low, but untreated tension pneumothorax or cardiac tamponade causes immediate ventilatory and circulatory failure and thereby worsens cerebral perfusion. The expected life-saving benefit, feasibility of immediate decompression, and low tolerance for delay support a strong recommendation, with explicit blood-pressure and cerebral-perfusion safeguards.

Tube thoracostomy is the standard initial treatment for hemothorax or hemopneumothorax and permits decompression, quantification of blood loss, and support for subsequent decision-making. A large-bore chest tube, such as a 28–42 F tube, is generally recommended.^{84,125-128,135-137}

Continuous monitoring is required after tube placement. Any of the following findings may indicate active hemorrhage and should prompt consideration of escalation of hemostatic treatment after multidisciplinary assessment and discussion of the risks with the patient's family:

- (1) Initial chest-tube output ≥ 1500 mL;
- (2) Ongoing output ≥ 200 mL/h; or
- (3) A continuing transfusion requirement to maintain circulatory stability.

Video-assisted thoracoscopic surgery or thoracotomy represents the principal method of hemorrhage control in these circumstances.^{126,136,137}

In patients who are relatively stable after resuscitation and in whom intercostal or chest-wall arterial bleeding is suspected, transcatheter arterial embolization is an effective minimally invasive option.^{138,139} In patients with retained or clotted hemothorax, early evacuation using video-assisted thoracoscopic surgery, such as within 4 days after injury, may reduce the risks of infection and fibrothorax.^{127,140}

Progressive shock or worsening ventilation should prompt active consideration of surgery even when the drainage-volume threshold has not been reached.^{125-128,135-137} Emergency management of suspected tension pneumothorax is described in Recommendation 1.^{17,22,141,142}

When TBI is also present, a life-threatening thoracic injury, such as tension pneumothorax, should be managed first, and treatment should not be delayed while awaiting imaging.^{84,127,141} Needle thoracic decompression may be performed at the fourth or fifth intercostal space in the midaxillary line.^{22,142}

In patients with cardiac arrest caused by cardiac tamponade, emergency thoracotomy may improve outcomes when the cause is considered reversible, although the indications must be strictly controlled.^{143,144} Prevention of secondary brain injury is critical in patients with concomitant TBI. During and after control of active hemorrhage, blood pressure should be actively maintained at cerebral-protection targets. When ICP cannot be monitored, this guideline uses an SBP of ≥ 110 mmHg or MAP of ≥ 80 mmHg as a conservative cerebral-protection target.^{13,63,65,66,74}

Abdominal and pelvic surgical strategies

Clinical question 19: When is simultaneous dual-team surgery appropriate, and when should sequential damage-control surgery be preferred?

Recommendation 19: In patients with head, thoracic, abdominal, and pelvic polytrauma, surgery should preferentially be performed sequentially, with the order determined by the most immediate threat, including ventilatory compromise, active massive hemorrhage, or the risk of cerebral herniation. Simultaneous surgery may be considered on an individualized basis only when a hybrid operating room, a multidisciplinary team, and the capacity for rigorous perioperative assessment are available; it should not be routinely applied. Institutions with limited resources should focus on rapidly establishing a hemorrhage-control pathway and optimizing transport rather than increasing procedural complexity and risk in an attempt to perform parallel interventions.

Strength of recommendation: II, weak recommendation
Quality of evidence: D, very low

The management of abdominal and pelvic hemorrhage should be centered on the patient's hemodynamic status and closely integrated with the principles of damage-control surgery and damage-control resuscitation.^{145,146}

In patients with high-grade hepatic or splenic injuries who are hemodynamically stable or become stable after resuscitation, nonoperative management combined with transcatheter arterial embolization should be the preferred strategy. Hemodynamically unstable patients require immediate damage-control surgery, including exploratory laparotomy and packing. After hypothermia, acidosis, and coagulopathy have been corrected in the ICU, staged definitive surgery should be performed.

For hollow-viscus or mesenteric injuries, the principle of prioritizing contamination control should be followed. During physiological derangement, rapid procedures, including primary repair or stoma formation, should be used to control contamination. Temporary abdominal closure may be performed when necessary, and complex anastomoses should be avoided during metabolic instability.

Hemorrhage associated with pelvic fracture should be managed using a stepwise strategy. Immediate mechanical stabilization of the pelvis, including placement of a pelvic binder or an external fixator, should be followed as rapidly as possible by transcatheter arterial embolization to control arterial bleeding. This pathway is consistent with relevant international guidelines.

In critically ill patients in whom conventional assessment and management cannot achieve rapid hemorrhage control, REBOA may be used by an experienced team, under strict time constraints, as a temporary bridge to definitive hemostasis. Balloon-occlusion time must be strictly limited to reduce the risk of distal ischemia.

When intracranial hypertension and active massive torso hemorrhage coexist, the decision to use sequential or simultaneous treatment should be made cautiously according to the patient's physiological condition and the resources available at the treating institution.

High-level comparative evidence is currently lacking. Available case reports and implementation studies suggest that simultaneous procedures on multidisciplinary or hybrid platforms are feasible and may reduce delays in care.^{94-96,147-149} However, evidence that these platforms improve survival or neurological outcomes in patients with concomitant severe TBI remains low quality and uncertain.¹⁵⁰⁻¹⁵³

Deaths in this population are most commonly caused by irreversible TBI or hemorrhagic shock.^{152,153} The safety and effectiveness of a simultaneous strategy are highly dependent on established multidisciplinary institutional pathways, robust life-support capabilities, and team experience. Decisions must be based on comprehensive multidisciplinary assessment and full communication with the patient's family.

Management of special populations and special circumstances

Management of head, thoracic, abdominal, and pelvic polytrauma in older adults

Clinical question 20: Which pathway adaptations are required for older adults with polytrauma?

Recommendation 20: Older patients with polytrauma are at increased risk because of reduced physiological reserve, multiple comorbidities, polypharmacy, and atypical clinical presentations. A comprehensive geriatric trauma management pathway is recommended to improve the process and outcomes of trauma care.

Strength of recommendation: I, strong recommendation

Quality of evidence: B, moderate

The management of polytrauma in older adults aged ≥ 65 years requires an integrated pathway centered on adjustment of triage criteria, strengthened medication management, prevention of complications, and development of an individualized treatment plan that respects the patient's preferences.¹⁵⁴⁻¹⁵⁸

- (1) **Triage and assessment:** Age ≥ 65 years should be considered a high-risk factor warranting activation of the trauma team. Even when vital signs do not meet conventional criteria for shock, assessment and resuscitation should be escalated in the presence of an SBP < 110 mmHg, altered mental status, hypothermia, or a blunted heart-rate response. Early frailty screening, such as use of the Clinical Frailty Scale, is suggested to assess physiological reserve.
- (2) **Communication and decision-making:** The patient and family should be informed as early as possible about the injuries, treatment options, and expected outcomes. In patients

with severe frailty, the intensity and boundaries of treatment should be discussed jointly in accordance with the patient's preferences.

- (3) **Medication management:** A systematic medication review must be conducted, with particular attention to anticoagulant or antiplatelet therapy and β -blocker use. Coagulation indices, including the international normalized ratio, should be measured as soon as possible. Appropriate anticoagulation-related management should be initiated promptly after risk assessment and in accordance with established pathways, in preparation for hemostatic procedures when required.
- (4) **Monitoring and prevention:** After adequate assessment and communication with the patient or family, invasive blood-pressure monitoring may be considered. A high index of suspicion should be maintained when determining the need for imaging of the thorax, abdomen, spine, and other potentially injured regions. Prevention of complications should focus on pulmonary infection, venous thrombosis, delirium, and functional deterioration. Nutritional assessment should be performed early, and respiratory exercises and rehabilitation should be initiated as soon as possible by a multidisciplinary team.

The panel recommends that each center monitor key process indicators, including the time to completion of diagnostic examinations, the time to initiation of anticoagulation-related management, and the incidence of complications. These consensus-based implementation indicators are intended to support continuous quality improvement and should be adapted to local resources and data systems.

Management of head, thoracic, abdominal, and pelvic polytrauma in battlefield environments

Clinical question 21: Which immediate hemorrhage-control measures should be prioritized in battlefield hot or warm zones?

Recommendation 21: In battlefield environments, including hot and warm zones, immediate on-site hemorrhage control using a tourniquet, junctional hemorrhage-control device, hemostatic dressing, hemostatic agent, or other appropriate method is strongly recommended for compressible external hemorrhage. Antishock management should be initiated concurrently.

Strength of recommendation: I, strong recommendation

Quality of evidence: B, moderate

An integrated management pathway comprising hemorrhage control, ventilation, circulation, craniocerebral management, and temperature control should be followed. The "survival triad" of immediate on-site hemorrhage control, concurrent antishock management, and rapid evacuation is essential for reducing mortality.¹⁵⁹⁻¹⁶⁴

Immediate on-site hemorrhage control is the first priority. A tourniquet should be used preferentially for compressible extremity hemorrhage, and the time of application should be documented. If bleeding persists, a second tourniquet should be applied proximal to the first.

For hemorrhage arising from the axilla, groin, or root of the

neck, manual compression combined with a kaolin- or chitosan-based hemostatic dressing is recommended, using wound packing followed by continuous compression for ≥ 3 min.^{161,163,165} If this approach is ineffective, a junctional hemorrhage-control device may be considered after appropriate assessment and communication.

For noncompressible torso hemorrhage, the casualty should be evacuated immediately after basic ventilation and temperature-preservation measures have been implemented to an institution capable of performing damage-control surgery or interventional hemorrhage control. Time-consuming on-site procedures should be avoided.

Antishock and comprehensive management should be implemented concurrently. These measures include restrictive fluid resuscitation, limitation of early crystalloid administration, transfusion of blood products as early as possible when available, prevention of hypothermia, correction of acidosis and coagulopathy, and establishment of a rapid evacuation pathway.

In extreme environments and during development of the trauma-care system, rapid and reliable hemorrhage-control measures should be prioritized under conditions such as darkness, cold, and ongoing combat. Hemorrhage-control devices should be secured during transport and reassessed regularly to ensure that they have not loosened.

Standardized training should be provided to all relevant personnel and should include self-aid and buddy aid, use of equipment, and recognition of complications. A system for recording use and conducting post-event reviews should be established. Limb perfusion and neurovascular function should be routinely monitored.

Core quality indicators may include the rate of tourniquet or hemostatic-dressing use, time to initial hemorrhage control, incidence of recurrent bleeding during transport, incidence of hypothermia, and 24-h mortality.

Role of artificial intelligence in prognostic assessment of head, thoracic, abdominal, and pelvic polytrauma

Clinical question 22: How should conventional prognostic models and artificial intelligence tools be used in TBI and polytrauma?

Recommendation 22: Prognostic prediction tools should be used to support risk stratification, prognostic communication, and treatment decision-making rather than as the sole basis for estimating an individual patient's prognosis. Established models, including the Corticosteroid Randomisation After Significant Head Injury (CRASH) and International Mission for Prognosis and Analysis of Clinical Trials in TBI (IMPACT) models, should serve as the foundation, and externally validated artificial intelligence methods may be used as supplementary tools. All decisions must integrate clinical assessment, concomitant injuries, patient preferences, and multidisciplinary discussion.

Strength of recommendation: II, weak recommendation

Quality of evidence: B, moderate

Perioperative prognostic stratification may assist in optimizing clinical decision-making and resource allocation. In patients with moderate-to-severe TBI, established models such as IMPACT and CRASH may be used to estimate the risk of mortality and unfavorable outcomes at 6 months.^{166,167} Their variables are readily obtainable and interpretable. However, the ability of these conventional models to account for complex clinical circumstances, including concomitant polytrauma, remains limited.

Machine-learning approaches have shown potential for outcome prediction, including the early prediction of harmful intracranial-pressure burden.¹⁶⁸ Alongside these developments, the CRASH and IMPACT models have undergone additional external validation in diverse populations.¹⁶⁹⁻¹⁷¹ Reviews of computational prognostic modeling and contemporary prediction models continue to identify insufficient external validation and methodological heterogeneity as barriers to clinical translation.¹⁷²⁻¹⁷⁴

For implementation, trauma centers are advised to use the CRASH and IMPACT models as foundational tools.¹⁷³⁻¹⁷⁵ Models adapted to local populations may be developed using local data, but they should undergo external validation before their outputs are integrated into multidisciplinary decisions regarding surgery or resuscitation.^{172,176-185} The development and reporting of such models should follow the TRIPOD+AI statement (TRIPOD, Transparent Reporting of a multivariable prediction model for Individual Prognosis Or Diagnosis).¹⁸⁶

Prognostic assessment should also contribute to quality improvement. A multidimensional quality-control system is suggested, incorporating:

- (1) **Process indicators**, such as trauma-team response time, time to completion of CT, and time to definitive surgery;
- (2) **Outcome indicators**, such as mortality and complication rates; and
- (3) **Structural indicators**, such as the availability of required resources.

Information technologies may be used for automated extraction of indicators and real-time alerts to support continuous pathway optimization.

Implementation, multidisciplinary team (MDT) operations, and quality control

MDT activation and command

Each institution should maintain an immediately activatable MDT pathway for adult patients with suspected injuries involving at least two major anatomical regions together with hemodynamic or respiratory instability, a GCS score ≤ 8 or progressive neurological deterioration, active hemorrhage, or a need to coordinate competing time-critical interventions. Pre-arrival activation should be used when these features are recognized during transport.

On activation, a single trauma team leader should be identified and documented. The leader should establish shared priorities, assign responsibilities, confirm physiological targets and contingency triggers, and use closed-loop communication. Brief MDT huddles should occur after the initial X-ABCDE assessment, after decisive imaging or a material change in physiology, before transfer to the operating room or interventional suite, and after completion of each critical procedure.

Responsibility allocation and communication pathway

The trauma team leader is responsible for overall sequencing and escalation. Emergency and anesthesiology teams are responsible for airway, ventilation, vascular access, transfusion, temperature control, and physiological monitoring. Neurosurgery is responsible for neurological assessment, intracranial pressure management, and cranial intervention. Thoracic, abdominal, pelvic, and interventional teams are responsible for definitive hemorrhage control within their respective domains. Radiology should support rapid protocol selection and image communication; critical care and nursing teams should maintain reassessment, medication, prophylaxis, documentation, and handoff continuity. Major decisions, dissent, and reasons for deviation from the pathway should be recorded in the medical record.

Indicator definitions, monitoring, and review

Quality indicators should use explicit operational definitions and denominators. Data should be captured at the patient level, summarized in a monthly dashboard, reviewed by the multidisciplinary quality committee at least quarterly, and used for an annual pathway review or earlier revision when a recurrent safety signal is identified. The core operational indicators are summarized in [Table 6](#).

Discussion and future directions

This guideline emphasizes that the management of head, thoracic, abdominal, and pelvic polytrauma fundamentally involves addressing the combined crisis of intracranial hypertension, massive torso hemorrhage, and multiorgan dysfunction. Effective care must therefore rely on standardized pathways and multidisciplinary teamwork.

The trauma-care framework is based on the principles of saving life first, protecting the brain thereafter, and simultaneously preserving function. During the early phase, the X-ABCDE assessment sequence should be followed, with priority given to control of external hemorrhage and management of tension pneumothorax, followed by completion of imaging assessment as rapidly as possible. The recommendations are summarized in [Table 3](#).

Damage control resuscitation is fundamental, and blood pressure targets should be adjusted according to whether severe TBI is present. The central principle of surgical decision-making is to address reversible causes of death.

When conditions permit, patients should preferentially be transferred to a hybrid operating room for coordinated hemorrhage control and decompressive procedures. In most circumstances, however, a sequential damage control surgical strategy should be adopted, comprising rapid control of hemorrhage, transfer to the ICU for resuscitation, and subsequent staged definitive reconstruction.

Perioperative management should continue throughout the entire treatment pathway and should include thrombosis prophylaxis, seizure prophylaxis, nutritional support, and early rehabilitation. Differentiated management should be provided for special populations, including older adults and patients receiving anticoagulant therapy.

Overall, this guideline provides a comprehensive management

strategy centered on the trauma team and focused on hemorrhage control and cerebral protection. It is intended to support timely, consistent multidisciplinary care and to provide a framework for improving survival and preserving functional outcomes within the critical treatment window.

Future management systems for head, thoracic, abdominal, and pelvic polytrauma are expected to become increasingly precise, coordinated, and intelligent. At the technological level, artificial intelligence–assisted image interpretation, monitoring and early warning based on vital signs, and big data–driven prognostic models may further improve the efficiency and accuracy of early assessment and decision-making.

At the system level, information sharing and pathway coordination among prehospital emergency services, primary-level hospitals, and regional trauma centers should be strengthened. Standardized tiered trauma-care and remote-consultation networks should be established.

At the research level, further studies should investigate optimal resuscitation targets, surgical sequencing, and perioperative management strategies for different combinations of injuries. Patient-centered studies evaluating functional outcomes are also required.

Continuous technological innovation, optimization of trauma-care systems, and high-quality clinical research will ultimately promote continued improvement in the overall management of polytrauma in China.

Conclusions

The management of head, thoracic, abdominal, and pelvic polytrauma requires rapid control of exsanguinating hemorrhage and life-threatening thoracic injury while preventing secondary brain injury. Damage control resuscitation, definitive hemorrhage control, and cerebral protection are the central principles of care, and the sequence of interventions should be individualized according to the most immediate reversible threat, the patient's physiological condition, and available institutional resources. Implementation of these recommendations requires multidisciplinary coordination, continuous reassessment, and standardized links between prehospital services, primary-level institutions, and regional trauma centers.

Acknowledgments

None.

Funding

This work was supported by the Major Program of the National Natural Science Foundation of China (Grant No. T2394483).

Conflicts of interest

YBY has been an Executive Associate Editor of *Neurosurgical Subspecialties* since September 2024. GYG has been an Editorial Board Member of *Neurosurgical Subspecialties* since August 2024. The authors declare that they have no other conflict of interest.

Table 6. Operational quality indicators for institutional implementation

Indicator	Operational definition	Measurement unit / denominator	Monitoring frequency	Accountable team
MDT activation latency	Time from recognition of eligibility to acknowledgment by the designated trauma-team leader	Each eligible patient; report median and 90th percentile	Case level; monthly dashboard	Trauma program / emergency department
Primary assessment completion	Time from arrival to documented completion of the initial X-ABCDE assessment and first reprioritization	Each eligible patient	Case level; monthly dashboard	Trauma-team leader
Imaging timeliness	Time from arrival to first indicated E-FAST examination and, in transport-safe patients, to completion of whole-body CT	Patients meeting the relevant imaging indication	Case level; monthly dashboard	Trauma team and radiology
Definitive hemorrhage-control interval	Time from arrival to surgical incision or initiation of the definitive interventional hemostatic procedure	Patients requiring operative or interventional hemorrhage control	Case level; monthly dashboard	Surgery / interventional radiology
Neurocritical decision interval	Time from recognition of cerebral herniation or refractory intracranial hypertension to the documented decompression decision and start of intervention	Patients meeting neurocritical escalation criteria	Case level; monthly dashboard	Neurosurgery and critical care
Physiological transition documentation	Documentation of SBP or MAP, temperature, PaCO ₂ , lactate, hemoglobin, coagulation indices, and ICP or CPP when available before and after repositioning or other critical procedural transitions	Each relevant procedure or transfer	Case level; monthly audit	Anesthesiology / operating-room team
VTE-prophylaxis decision	Documented pharmacological and mechanical prophylaxis decision after repeat imaging and bleeding-risk assessment, including reasons for delay or withholding	All ICU-admitted patients with polytrauma	Within 24 h and after material clinical change; monthly audit	ICU, trauma, and neurosurgery teams
Outcome and safety indicators	In-hospital mortality, potentially preventable death, unplanned reoperation or intervention, VTE, major bleeding, and transfusion-related complications	All eligible patients, risk adjusted where feasible	Continuous capture; quarterly review	Trauma quality committee
Pathway-deviation review	Structured review of omitted or delayed pathway steps, documented reasons, contributing system factors, and corrective actions	All deaths and major complications plus a representative sample of other cases	Quarterly; annual pathway revision	Multidisciplinary quality committee

CPP, cerebral perfusion pressure; CT, computed tomography; E-FAST, extended focused assessment with sonography for trauma; ICP, intracranial pressure; ICU, intensive care unit; MAP, mean arterial pressure; MDT, multidisciplinary team; PaCO₂, arterial partial pressure of carbon dioxide; SBP, systolic blood pressure; VTE, venous thromboembolism; X-ABCDE, exsanguination control, airway/cervical spine protection, breathing, circulation, disability, and exposure.

Author contributions

Conceived and supervised the guideline project, provided overall academic leadership, critically

reviewed and approved the manuscript (JNZ), served as deputy chairs of the guideline development group and contributed to the overall design, methodological coordination, formulation of clinical questions, development of recommendations, and critical revision of the manuscript (WJ, YBY), coordinated the evidence synthesis and guideline drafting process, and

wrote the original manuscript (JYL). All other authors contributed to the multidisciplinary expert consultation, interpretation of the evidence, formulation and revision of the recommendations, consensus discussions and voting, and critical review of the manuscript. All authors reviewed and approved the final version of the manuscript and agreed to be accountable for the integrity and accuracy of the work.

Guideline registration

This guideline was registered with PREPARE under registration number PREPARE-2025CN1273.

Guideline Development Group

Chair

Jian-Ning Zhang (Senior Department of Neurosurgery, Chinese PLA General Hospital)

Vice Chairs

Wang Jia (Department of Neurosurgery, Beijing Tiantan Hospital, Capital Medical University); Yan-Bing Yu (Department of Neurosurgery, China-Japan Friendship Hospital)

Lead Writer

Jia-Yu Liu (Senior Department of Neurosurgery, Chinese PLA General Hospital)

Secretariat

Gang Cheng (Senior Department of Neurosurgery, Chinese PLA General Hospital); Yu-Xin Wang (Senior Department of Neurosurgery, Chinese PLA General Hospital); Ming Zhao (Senior Department of Neurosurgery, Chinese PLA General Hospital); Wen-Ying Lv (Senior Department of Neurosurgery, Chinese PLA General Hospital); Jun-Zhao Sun (Senior Department of Neurosurgery, Chinese PLA General Hospital)

Expert Panel Members

The expert panel members are listed alphabetically by Hanyu Pinyin:

Jiang-Bei Cao (Department of Anesthesiology, the First Medical Center, Chinese PLA General Hospital); Wei-Dong Cao (Senior Department of Neurosurgery, Chinese PLA General Hospital); Cheng-Long Chen (Department of Orthopedics, Beijing Jishuitan Hospital, Capital Medical University); Gang Chen (Department of Anesthesiology, the First Medical Center, Chinese PLA General Hospital); Hao Chen (Department of Neurosurgery, Shanghai Sixth People's Hospital Affiliated to Shanghai Jiao Tong University School of Medicine); Ke-Zhong Chen (Department of Thoracic Surgery, Peking University People's Hospital); Wei Chen (Department of Neurosurgery, the First Affiliated Hospital of Xi'an Jiaotong University); Wen-Li Chen (Department of Neurosurgery, the Sixth Affiliated Hospital of Sun Yat-sen University); Chong-Jie Cheng (Department of Neurosurgery, the First Affiliated Hospital of Chongqing Medical University); Gang Cheng (Senior Department of Neurosurgery, Chinese PLA General Hospital); Dan-Dong Fang (Department of Neurosurgery, Sanmenxia Central Hospital); Wen-Hua Fang (Department of Neurosurgery, the First Affiliated Hospital of Fujian Medical

University); Zhou Fei (Department of Neurosurgery, the First Affiliated Hospital of Air Force Medical University); Ya-Ping Feng (Department of Neurosurgery, the 920th Hospital of the Joint Logistics Support Force); Cong Feng (Senior Department of Neurosurgery, Chinese PLA General Hospital); Hua Feng (Department of Neurosurgery, Southwest Hospital, Army Medical University); Guo-Yi Gao (Department of Neurosurgery, Beijing Tiantan Hospital, Capital Medical University); Yuan Gao (Nursing Department, the First Medical Center, Chinese PLA General Hospital); Cai-Bin Gao (Department of Neurosurgery, General Hospital of Ningxia Medical University); Yong-Xin Guo (Department of Anesthesiology, the First Medical Center, Chinese PLA General Hospital); Bo-Ru Hou (Department of Neurosurgery, Lanzhou University Second Hospital); Rong Hu (Department of Neurosurgery, Southwest Hospital, Army Medical University); Zhen Ji (Senior Department of Neurosurgery, Chinese PLA General Hospital); Bao-Qing Jia (Senior Department of General Surgery, Chinese PLA General Hospital); Wang Jia (Department of Neurosurgery, Beijing Tiantan Hospital, Capital Medical University); Ji-Peng Jiang (Department of Thoracic Surgery, the First Medical Center, Chinese PLA General Hospital); Rong-Cai Jiang (Department of Neurosurgery, Xuanwu Hospital, Capital Medical University); Chuan-Lu Jiang (Department of Neurosurgery, the Second Affiliated Hospital of Harbin Medical University); De-Zhi Kang (Department of Neurosurgery, the First Affiliated Hospital of Fujian Medical University); Jun Kang (Department of Neurosurgery, Beijing Tongren Hospital, Capital Medical University); Tan-Shi Li (Department of Emergency Medicine, the First Medical Center, Chinese PLA General Hospital); Fei Li (Department of Neurosurgery, Southwest Hospital, Army Medical University); Ji Li (Senior Department of Orthopedics, Chinese PLA General Hospital); Jia Li (Senior Department of Orthopedics, Chinese PLA General Hospital); Shi-Jun Li (Department of Radiology, the First Medical Center, Chinese PLA General Hospital); Ye Li (Xuanwu Hospital, Capital Medical University); Xiang-Dang Liang (Senior Department of Orthopedics, Chinese PLA General Hospital); Hai-Xiao Liu (Department of Neurosurgery, the Second Affiliated Hospital of Air Force Medical University); Jia-Yu Liu (Senior Department of Neurosurgery, Chinese PLA General Hospital); Jin-Fang Liu (Department of Neurosurgery, Xiangya Hospital, Central South University); Mei-Jing Liu (Senior Department of Neurosurgery, Chinese PLA General Hospital); Wei-Nan Liu (Department of General Surgery, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College); Zhi-Yong Liu (Department of Neurosurgery and Trauma Medical Center, West China Hospital, Sichuan University); Xin Lou (Department of Radiology, the First Medical Center, Chinese PLA General Hospital); Yong-Xin Luan (Department of Neurosurgery, the First Hospital of Jilin University); Wen-Ying Lv (Senior Department of Neurosurgery, Chinese PLA General Hospital); Si-Qi Ma (Department of Neurosurgery, the First Affiliated Hospital of Zhengzhou University); Xiao-Hai Ma (Department of Medical Imaging, Beijing Anzhen Hospital, Capital Medical University); Yong-Fu Ma (Department of Thoracic Surgery, the First Medical Center, Chinese PLA General Hospital); Yue Ma (Department of Neurosurgery, Qinghai Provincial People's Hospital); Xiang Mao

(Department of Neurosurgery, the First Affiliated Hospital of Anhui Medical University); Wei-Dong Mi (Department of Anesthesiology, the First Medical Center, Chinese PLA General Hospital); Hong-Quan Niu (Department of Neurosurgery, Tongji Hospital, Tongji Medical College, Huazhong University of Science and Technology); Yu-Chun Pei (Department of Neurosurgery, the Second Affiliated Hospital of Army Medical University); Zhi Qiao (Senior Department of General Surgery, Chinese PLA General Hospital); Guo-Chen Sun (Senior Department of Neurosurgery, Chinese PLA General Hospital); Jian Sun (Department of Neurosurgery, Tianjin Medical University General Hospital); Jun-Zhao Sun (Senior Department of Neurosurgery, Chinese PLA General Hospital); Yong-Xin Wang (Department of Neurosurgery, the First Affiliated Hospital of Xinjiang Medical University); Chun-Hong Wang (Department of Neurosurgery, Shanxi Provincial People's Hospital); Fei Wang (Department of Neurosurgery, the Affiliated Hospital of Inner Mongolia Medical University); Jun-Song Wang (Senior Department of Orthopedics, Chinese PLA General Hospital); Lei Wang (Department of Emergency Medicine, Beijing Tongren Hospital, Capital Medical University); Ning Wang (Department of Neurosurgery, Xuanwu Hospital, Capital Medical University); Qun Wang (Department of Neurosurgery, Beijing Tiantan Hospital, Capital Medical University); Yi-Long Wang (Department of Neurosurgery, Beijing Tiantan Hospital, Capital Medical University); Yu-Xin Wang (Senior Department of Neurosurgery, Chinese PLA General Hospital); Jun-Ji Wei (Department of Neurosurgery, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College); Liang Wen (Department of Neurosurgery, the First Affiliated Hospital, Zhejiang University School of Medicine); Jian-Liang Wu (Department of Neurosurgery, Handan Central Hospital); Zhuo Xi (Department of Neurosurgery, Shengjing Hospital of China Medical University); Tian-Yu Xie (Senior Department of General Surgery, Chinese PLA General Hospital); Dong Xing (Department of Anesthesiology, the First Affiliated Hospital of Air Force Medical University); Qiang Xu (Department of General Surgery, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences & Peking Union Medical College); Zhi-Qiang Xue (Department of Thoracic Surgery, the First Medical Center, Chinese PLA General Hospital); Hua Yan (Department of Neurosurgery, Huanhu Hospital Affiliated to Tianjin Medical University); Xuan-Yong Yang (the First Affiliated Hospital of Nanchang University); Yan-Bing Yu (Department of Neurosurgery, China-Japan Friendship Hospital); Yu-Song Yuan (Department of Trauma Orthopedics, China-Japan Friendship Hospital); Dan-Feng Zhang (Department of Neurosurgery, the Second Affiliated Hospital of Naval Medical University); Guo-Bin Zhang (Department of Craniocerebral Trauma and Critical Care Medicine, Huanhu Hospital Affiliated to Tianjin Medical University); Jian-Ning Zhang (Senior Department of Neurosurgery, Chinese PLA General Hospital); Jiu-Xiang Zhang (Department of Anesthesiology, the First Affiliated Hospital of Air Force Medical University); You-San Zhang (Department of Neurosurgery, Mianchi County People's Hospital, Sanmenxia, Henan); Dong Zhao (Department of Critical Care Medicine, Beijing Tongren Hospital, Capital Medical University); Guang-Chao Zhao (Department of Anesthesiology, the First

Affiliated Hospital of Air Force Medical University); Ming Zhao (Senior Department of Neurosurgery, Chinese PLA General Hospital); Xiao-Que Zheng (Senior Department of Neurosurgery, Chinese PLA General Hospital); Zhuo-Zhao Zheng (Department of Radiology, Beijing Tsinghua Changgung Hospital); Fei-Hu Zhou (Department of Critical Care Medicine, the First Medical Center, Chinese PLA General Hospital); Jie Zhou (Department of Neurosurgery, the 940th Hospital of the Joint Logistics Support Force); Meng-Liang Zhou (Department of Neurosurgery, General Hospital of the Eastern Theater Command); Hai-Yan Zhu (Department of Emergency Medicine, the First Medical Center, Chinese PLA General Hospital); Hong-Wei Zhu (Department of Neurosurgery, the First Affiliated Hospital of Xiamen University); and Qiao Zuo (Neurovascular Center, the First Affiliated Hospital of Naval Medical University).

References

- [1] James SL, Castle CD, Dingels ZV, Fox JT, Hamilton EB, Liu Z, *et al*. Global injury morbidity and mortality from 1990 to 2017: results from the Global Burden of Disease Study 2017. *Inj Prev* 2020; 26(Suppl 1):i96–i114. DOI: 10.1136/injuryprev-2019-043494, PMID: 32332142.
- [2] Gu D, Ou S, Liu G. Global burden of road injuries and their attributable risk factors from 1990 to 2021: A systematic analysis for the global burden of disease study 2021. *Prev Med Rep* 2025; 53:103051. DOI: 10.1016/j.pmedr.2025.103051, PMID: 40235577.
- [3] World Health Organization. Global status report on road safety 2023. Geneva: World Health Organization; 2023.
- [4] Pfeifer R, Tarkin IS, Rocos B, Pape HC. Patterns of mortality and causes of death in polytrauma patients--has anything changed? *Injury* 2009;40(9):907–911. DOI: 10.1016/j.injury.2009.05.006, PMID: 19540488.
- [5] Karajizadeh M, Yadollahi M, Yousefi MR, Bordbar N. Mortality risk factors in chest trauma patients in a level one trauma center in southern Iran. *Sci Rep* 2025;15(1):32310. DOI: 10.1038/s41598-025-13830-6, PMID: 40897725.
- [6] Lundin A, Akram SK, Berg L, Göransson KE, Enocson A. Thoracic injuries in trauma patients: epidemiology and its influence on mortality. *Scand J Trauma Resusc Emerg Med* 2022;30(1):69. DOI: 10.1186/s13049-022-01058-6, PMID: 36503613.
- [7] Yahyoev SMO, Khodzimatov GM. Diagnostic methods and surgical treatment of patients with thoracoabdominal traumas (review of the literature). *Kardiochir Torakochirurgia Pol* 2022;19(4):226–231. DOI: 10.5114/kitp.2022.122093, PMID: 36643345.
- [8] Wang Y, Wang C, Hu P, Wang H, Gan L, Kong G, *et al*. China trauma treatment statistics 2019: A national retrospective study based on hospitalized cases. *Front Public Health* 2023;11:1116828. DOI: 10.3389/fpubh.2023.1116828, PMID: 36908445.
- [9] Duan L, Yu M, Zhao M, Wu J. Enhancing Injury Prevention and Control in China: Establishment of Evidence System. *China CDC Wkly* 2023;5(47):1063–1066. DOI: 10.46234/ccdcw2023.199, PMID: 38047246.
- [10] Gennarelli TA, Wodzin E. AIS 2005: a contemporary injury scale. *Injury* 2006;37(12):1083–1091. DOI: 10.1016/j.injury.2006.07.009, PMID: 17092503.
- [11] Rapsang AG, Shyam DC. Scoring systems of severity in patients with multiple trauma. *Cir Esp* 2015;93(4):213–221. DOI: 10.1016/j.ciresp.2013.12.021, PMID: 25015031.

- [12] Lesko MM, Woodford M, White L, O'Brien SJ, Childs C, Lecky FE. Using Abbreviated Injury Scale (AIS) codes to classify Computed Tomography (CT) features in the Marshall System. *BMC Med Res Methodol* 2010;10:72. DOI: 10.1186/1471-2288-10-72, PMID: 20691038.
- [13] Carney N, Totten AM, O'Reilly C, Ullman JS, Hawryluk GW, Bell MJ, *et al*. Guidelines for the Management of Severe Traumatic Brain Injury, Fourth Edition. *Neurosurgery* 2017;80(1):6–15. DOI: 10.1227/NEU.0000000000001432, PMID: 27654000.
- [14] Hawryluk GWJ, Rubiano AM, Totten AM, O'Reilly C, Ullman JS, Bratton SL, *et al*. Guidelines for the Management of Severe Traumatic Brain Injury: 2020 Update of the Decompressive Craniectomy Recommendations. *Neurosurgery* 2020;87(3):427–434. DOI: 10.1093/neuros/nyaa278, PMID: 32761068.
- [15] Spering C, Lehmann W. Severe Thoracic Trauma Indications and Contraindications for Non-operative and Operative Treatment Strategies (in German). *Zentralbl Chir* 2024;149(4):368–377. DOI: 10.1055/a-2348-0638, PMID: 39111302.
- [16] Loggers SAI, Koedam TWA, Giannakopoulos GF, Vandewalle E, Erwtaman M, Zuidema WP. Definition of hemodynamic stability in blunt trauma patients: a systematic review and assessment amongst Dutch trauma team members. *Eur J Trauma Emerg Surg* 2017;43(6):823–833. DOI: 10.1007/s00068-016-0744-8, PMID: 27900417.
- [17] American College of Surgeons Committee on Trauma. Advanced Trauma Life Support (ATLS) Student Course Manual. 10th ed. Chicago, IL: American College of Surgeons; 2018.
- [18] Polytrauma Guideline Update Group. Level 3 guideline on the treatment of patients with severe/multiple injuries: AWMF Register-Nr. 012/019. *Eur J Trauma Emerg Surg* 2018;44(Suppl 1):3–271. DOI: 10.1007/s00068-018-0922-y, PMID: 29654333.
- [19] Ahmad I, El-Boghdady K, Iliff H, Dua G, Higgs A, Huntington M, *et al*. Difficult Airway Society 2025 guidelines for management of unanticipated difficult tracheal intubation in adults. *Br J Anaesth* 2026;136(1):283–307. DOI: 10.1016/j.bja.2025.10.006, PMID: 41203471.
- [20] Jagannathan N, Aziz MF. Difficult Airway Society 2025 guidelines for tracheal intubation: thoughtful preparation for success and systematic management of failure. *Br J Anaesth* 2026;136(1):9–11. DOI: 10.1016/j.bja.2025.11.003, PMID: 41339170.
- [21] Waydhas C, Prediger B, Kamp O, Kleber C, Nohl A, Schulz-Drost S, *et al*. Prehospital management of chest injuries in severely injured patients-a systematic review and clinical practice guideline update. *Eur J Trauma Emerg Surg* 2024;50(4):1367–1380. DOI: 10.1007/s00068-024-02457-3, PMID: 38308661.
- [22] Ahmad SJS, Degiannis JR, Head M, Ahmed AR, Gelber E, Hakky S, *et al*. Meta-analysis of the optimal needle length and decompression site for tension pneumothorax and consensus recommendations on current ATLS and ETC guidelines. *World J Emerg Surg* 2025;20(1):39. DOI: 10.1186/s13017-025-00613-7, PMID: 40383767.
- [23] Verhoeff K, Saybel R, Mathura P, Tsang B, Fawcett V, Widder S. Ensuring adequate vascular access in patients with major trauma: a quality improvement initiative. *BMJ Open Qual* 2018;7(1):e000090. DOI: 10.1136/bmjopen-2017-000090, PMID: 29333494.
- [24] Johnston AJ, Simpson MJ, McCormack V, Barton A, Bennett J, Chalisey A, *et al*. Association of Anaesthetists guidelines: safe vascular access 2025. *Anaesthesia* 2025;80(11):1381–1396. DOI: 10.1111/anae.16727, PMID: 40958714.
- [25] Sierink JC, Treskes K, Edwards MJ, Beuker BJ, den Hartog D, Hohmann J, *et al*. Immediate total-body CT scanning versus conventional imaging and selective CT scanning in patients with severe trauma (REACT-2): a randomised controlled trial. *Lancet* 2016;388(10045):673–683. DOI: 10.1016/S0140-6736(16)30932-1, PMID: 27371185.
- [26] Wirth S, Hebebrand J, Basilico R, Berger FH, Blanco A, Calli C, *et al*. European Society of Emergency Radiology: guideline on radiological polytrauma imaging and service (short version). *Insights Imaging* 2020;11(1):135. DOI: 10.1186/s13244-020-00947-7, PMID: 33301105.
- [27] American College of Surgeons Committee on Trauma. ACS TQIP Best Practices Guidelines in Imaging. Chicago, IL: American College of Surgeons; 2018.
- [28] Fathi M, Mirjafari A, Yaghoobpoor S, Ghanikolahloo M, Sadeghi Z, Bahrami A, *et al*. Diagnostic utility of whole-body computed tomography/pan-scan in trauma: a systematic review and meta-analysis study. *Emerg Radiol* 2024;31(2):251–268. DOI: 10.1007/s10140-024-02213-5, PMID: 38396199.
- [29] Green SP, Al-Saedy S, Thomas EC, Glaser J. The Utility of Whole Body Computed Tomography in Trauma Activations and the Impact of Incidental Findings on Patient Management: A Review. *Cureus* 2024;16(10):e72798. DOI: 10.7759/cureus.72798, PMID: 39618586.
- [30] Yamamoto R, Suzuki M, Funabiki T, Sasaki J. Immediate CT after hospital arrival and decreased in-hospital mortality in severely injured trauma patients. *BJS Open* 2023;7(1):zrac133. DOI: 10.1093/bjsopen/zrac133, PMID: 36680778.
- [31] Valcarcel CR, Bieler D, Bass GA, Gaarder C, Hildebrand F; ESTES Polytrauma Consensus Group. ESTES recommendations for the treatment of polytrauma-a European consensus based on the German S3 guidelines for the treatment of patients with severe/multiple injuries. *Eur J Trauma Emerg Surg* 2025;51(1):171. DOI: 10.1007/s00068-025-02852-4, PMID: 40214785.
- [32] Treskes K, Saltzherr TP, Edwards MJR, Beuker BJA, Van Lieshout EMM, Hohmann J, *et al*. Refining the criteria for immediate total-body CT after severe trauma. *Eur Radiol* 2020;30(5):2955–2963. DOI: 10.1007/s00330-019-06503-2, PMID: 31974691.
- [33] Hanzalova I, Bourgeat M, Demartines N, Ageron FX, Zingg T. The use of whole body computed tomography does not lead to increased 24-h mortality in severely injured patients in circulatory shock. *Sci Rep* 2024;14(1):2169. DOI: 10.1038/s41598-024-52657-5, PMID: 38272956.
- [34] Flammia F, Chiti G, Trinci M, Danti G, Cozzi D, Grassi R, *et al*. Optimization of CT protocol in polytrauma patients: an update. *Eur Rev Med Pharmacol Sci* 2022;26(7):2543–2555. DOI: 10.26355/eur_rev_202204_28491, PMID: 35442469.
- [35] Arruzza E, Chau M, Dizon J. Systematic review and meta-analysis of whole-body computed tomography compared to conventional radiological procedures of trauma patients. *Eur J Radiol* 2020;129:109099. DOI: 10.1016/j.ejrad.2020.109099, PMID: 32563164.
- [36] Qi J, Bao L, Yang P, Chen D. Comparison of base excess, lactate and pH predicting 72-h mortality of multiple trauma. *BMC Emerg Med* 2021;21(1):80. DOI: 10.1186/s12873-021-00465-9, PMID: 34233612.
- [37] Gale SC, Kocik JF, Creath R, Crystal JS, Dombrovskiy VY. A comparison of initial lactate and initial base deficit as predictors of mortality after severe blunt trauma. *J Surg Res* 2016;205(2):446–455. DOI: 10.1016/j.jss.2016.06.103, PMID: 27664895.
- [38] Mutschler M, Nienaber U, Brockamp T, Wafaisade A, Fabian T, Paffrath T, *et al*. Renaissance of base deficit for the initial assessment of trauma patients: a base deficit-based classification for hypovolemic shock developed on data from 16,305 patients

- derived from the TraumaRegister DGU®. *Crit Care* 2013;17(2):R42. DOI: 10.1186/cc12555, PMID: 23497602.
- [39] Ward CL, Olafson SN, Cohen RB, Kaplan MJ, Bloom A, Parsikia A, *et al*. Combination of Lactate and Base Deficit Levels at Admission to Predict Mortality in Blunt Trauma Patients. *Cureus* 2023;15(6):e40097. DOI: 10.7759/cureus.40097, PMID: 37425498.
- [40] Salottolo KM, Mains CW, Offner PJ, Bourg PW, Bar-Or D. A retrospective analysis of geriatric trauma patients: venous lactate is a better predictor of mortality than traditional vital signs. *Scand J Trauma Resusc Emerg Med* 2013;21:7. DOI: 10.1186/1757-7241-21-7, PMID: 23410202.
- [41] Dezman ZD, Comer AC, Smith GS, Narayan M, Scalea TM, Hirshon JM. Failure to clear elevated lactate predicts 24-hour mortality in trauma patients. *J Trauma Acute Care Surg* 2015;79(4):580–585. DOI: 10.1097/TA.0000000000000810, PMID: 26402531.
- [42] Tisherman SA, Barie P, Bokhari F, Bonadies J, Daley B, Diebel L, *et al*. Clinical practice guideline: endpoints of resuscitation. *J Trauma* 2004;57(4):898–912. DOI: 10.1097/01.ta.0000133577.25793.e5, PMID: 15514553.
- [43] Rossaint R, Afshari A, Bouillon B, Cerny V, Cimpoesu D, Curry N, *et al*. The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition. *Crit Care* 2023;27(1):80. DOI: 10.1186/s13054-023-04327-7, PMID: 36859355.
- [44] Holcomb JB, Tilley BC, Baraniuk S, Fox EE, Wade CE, Podbielski JM, *et al*. Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs a 1:1:2 ratio and mortality in patients with severe trauma: the PROPPR randomized clinical trial. *JAMA* 2015;313(5):471–482. DOI: 10.1001/jama.2015.12, PMID: 25647203.
- [45] Camazine MN, Hemmila MR, Leonard JC, Jacobs RA, Horst JA, Kozar RA, *et al*. Massive transfusion policies at trauma centers participating in the American College of Surgeons Trauma Quality Improvement Program. *J Trauma Acute Care Surg* 2015;78(6 Suppl 1):S48–S53. DOI: 10.1097/TA.0000000000000641, PMID: 26002263.
- [46] Consunji R, Elseed A, El-Menyar A, Sathian B, Rizoli S, Al-Thani H, *et al*. The effect of massive transfusion protocol implementation on the survival of trauma patients: a systematic review and meta-analysis. *Blood Transfus* 2020;18(6):434–445. DOI: 10.2450/2020.0065-20, PMID: 32955420.
- [47] Meneses E, Boneva D, McKenney M, Elkbuli A. Massive transfusion protocol in adult trauma population. *Am J Emerg Med* 2020;38(12):2661–2666. DOI: 10.1016/j.ajem.2020.07.041, PMID: 33071074.
- [48] Lin TL, Liu HT, Hsieh CH. Current controversies and advances in massive transfusion: Balancing evidence and practice. *J Formos Med Assoc* 2025; S0929-6646(25)00383-3. DOI: 10.1016/j.jfma.2025.07.016, PMID: 40683811.
- [49] Davenport R, Curry N, Fox EE, Thomas H, Lucas J, Evans A, *et al*. Early and Empirical High-Dose Cryoprecipitate for Hemorrhage After Traumatic Injury: The CRYOSTAT-2 Randomized Clinical Trial. *JAMA* 2023;330(19):1882–1891. DOI: 10.1001/jama.2023.21019, PMID: 37824155.
- [50] Curry N, Davenport R, Thomas H, Fox E, Lucas J, Evans A, *et al*. Early high-dose cryoprecipitate to reduce mortality in adult patients with traumatic haemorrhage: the CRYOSTAT-2 RCT with cost-effectiveness analysis. *Health Technol Assess* 2024;28(76):1–69. DOI: 10.3310/JYTR6938, PMID: 39545850.
- [51] Hofer S, Schlump CJ, Casu S, Grouzi E. Management of Coagulopathy in Bleeding Patients. *J Clin Med* 2021;11(1):1. DOI: 10.3390/jcm11010001, PMID: 35011742.
- [52] Fries D, Martini WZ. Role of fibrinogen in trauma-induced coagulopathy. *Br J Anaesth* 2010;105(2):116–121. DOI: 10.1093/bja/aeq161, PMID: 20627882.
- [53] Spahn DR, Bouillon B, Cerny V, Duranteau J, Filipescu D, Hunt BJ, *et al*. The European guideline on management of major bleeding and coagulopathy following trauma: fifth edition. *Crit Care* 2019;23(1):98. DOI: 10.1186/s13054-019-2347-3, PMID: 30917843.
- [54] Rossaint R, Bouillon B, Cerny V, Coats TJ, Duranteau J, Fernández-Mondéjar E, *et al*. The European guideline on management of major bleeding and coagulopathy following trauma: fourth edition. *Crit Care* 2016;20:100. DOI: 10.1186/s13054-016-1265-x, PMID: 27072503.
- [55] Tsan SEH, Viknaswaran NL, Cheong CC, Cheah S, Ng KT, Mong SXY, *et al*. Prophylactic intravenous tranexamic acid and thromboembolism in non-cardiac surgery: a systematic review, meta-analysis and trial sequential analysis. *Anaesthesia* 2023; 78(9):1153–1161. DOI: 10.1111/anae.16058, PMID: 37314744.
- [56] Park LJ, Marcucci M, Ofori SN, Borges FK, Nenshi R, Kanstrup CTB, *et al*. Safety and Efficacy of Tranexamic Acid in General Surgery. *JAMA Surg* 2025;160(3):267–274. DOI: 10.1001/jamasurg.2024.6048, PMID: 39813061.
- [57] Shakur H, Roberts I, Bautista R, Caballero J, Coats T, Dewan Y, *et al*. Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial. *Lancet* 2010; 376(9734):23–32. DOI: 10.1016/S0140-6736(10)60835-5, PMID: 20554319.
- [58] Ker K, Sentilhes L, Shakur-Still H, Madar H, Deneux-Tharaux C, Saade G, *et al*. Tranexamic acid for postpartum bleeding: a systematic review and individual patient data meta-analysis of randomised controlled trials. *Lancet* 2024;404(10463):1657–1667. DOI: 10.1016/S0140-6736(24)02102-0, PMID: 39461793.
- [59] CRASH-3 trial collaborators. Effects of tranexamic acid on death, disability, vascular occlusive events and other morbidities in patients with acute traumatic brain injury (CRASH-3): a randomised, placebo-controlled trial. *Lancet* 2019;394(10210):1713–1723. DOI: 10.1016/S0140-6736(19)32233-0, PMID: 31623894.
- [60] Poeran J, Chan JJ, Zubizarreta N, Mazumdar M, Galatz LM, Mouchar CS. Safety of Tranexamic Acid in Hip and Knee Arthroplasty in High-risk Patients. *Anesthesiology* 2021;135(1):57–68. DOI: 10.1097/ALN.0000000000003772, PMID: 33857300.
- [61] Breau RH, Lavallée LT, Cagiannos I, Momoli F, Bryson GL, Kanji S, *et al*. Tranexamic Acid During Radical Cystectomy: A Randomized Clinical Trial. *JAMA Surg* 2024;159(12):1355–1363. DOI: 10.1001/jamasurg.2024.4183, PMID: 39356537.
- [62] Mahmood A, Roberts I, Shakur H. A nested mechanistic sub-study into the effect of tranexamic acid versus placebo on intracranial haemorrhage and cerebral ischaemia in isolated traumatic brain injury: study protocol for a randomised controlled trial (CRASH-3 Trial Intracranial Bleeding Mechanistic Sub-Study [CRASH-3 IBMS]). *Trials* 2017;18(1):330. DOI: 10.1186/s13063-017-2073-6, PMID: 28716153.
- [63] Lee JW, Wang W, Rezk A, Mohammed A, Macabudbud K, Englesakis M, *et al*. Hypotension and Adverse Outcomes in Moderate to Severe Traumatic Brain Injury: A Systematic Review and Meta-Analysis. *JAMA Netw Open* 2024;7(11):e2444465. DOI: 10.1001/jamanetworkopen.2024.44465, PMID: 39527054.
- [64] Rauch S, Marzolo M, Cappello TD, Ströhle M, Mair P, Pietsch U, *et al*. Severe traumatic brain injury and hypotension is a frequent and lethal combination in multiple trauma patients in mountain areas -

- an analysis of the prospective international Alpine Trauma Registry. *Scand J Trauma Resusc Emerg Med* 2021;29(1):61. DOI: 10.1186/s13049-021-00879-1, PMID: 33931076.
- [65] Jain V, Choudhary J, Pandit R. Blood Pressure Target in Acute Brain Injury. *Indian J Crit Care Med* 2019;23(Suppl 2):S136–S139. DOI: 10.5005/jp-journals-10071-23191, PMID: 31485122.
- [66] Stein KY, Gomez A, Griesdale D, Sekhon M, Bernard F, Gallagher C, *et al*. Cerebral physiologic insult burden in acute traumatic neural injury: a Canadian High Resolution-TBI (CAHR-TBI) descriptive analysis. *Crit Care* 2024;28(1):294. DOI: 10.1186/s13054-024-05083-y, PMID: 39232842.
- [67] Schick MA, Burek M, Förster CY, Nagai M, Wunder C, Neuhaus W. Hydroxyethylstarch revisited for acute brain injury treatment. *Neural Regen Res* 2021;16(7):1372–1376. DOI: 10.4103/1673-5374.300978, PMID: 33318420.
- [68] Wang G, Zhang H, Liu D, Wang X; Chinese Critical Ultrasound Study Group. Resuscitation fluids as drugs: targeting the endothelial glycocalyx. *Chin Med J (Engl)* 2022;135(2):137–144. DOI: 10.1097/CM9.0000000000001869, PMID: 34985018.
- [69] Dutton RP, Mackenzie CF, Scalea TM. Hypotensive resuscitation during active hemorrhage: impact on in-hospital mortality. *J Trauma* 2002;52(6):1141–1146. DOI: 10.1097/00005373-200206000-00020, PMID: 12045644.
- [70] Bickell WH, Wall MJ Jr, Pepe PE, Martin RR, Ginger VF, Allen MK, *et al*. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *N Engl J Med* 1994; 331(17):1105–1109. DOI: 10.1056/NEJM199410273311701, PMID: 7935634.
- [71] Kudo D, Yoshida Y, Kushimoto S. Permissive hypotension/hypotensive resuscitation and restricted/controlled resuscitation in patients with severe trauma. *J Intensive Care* 2017;5(1):11. DOI: 10.1186/s40560-016-0202-z, PMID: 34798698.
- [72] Toro C, Temkin N, Barber J, Manley G, Jain S, Ohnuma T, *et al*. Association of Vasopressor Choice with Clinical and Functional Outcomes Following Moderate to Severe Traumatic Brain Injury: A TRACK-TBI Study. *Neurocrit Care* 2022;36(1):180–191. DOI: 10.1007/s12028-021-01280-7, PMID: 34341913.
- [73] Hylands M, Toma A, Beaudoin N, Frenette AJ, D'Aragon F, Belley-Côté É, *et al*. Early vasopressor use following traumatic injury: a systematic review. *BMJ Open* 2017;7(11):e017559. DOI: 10.1136/bmjopen-2017-017559, PMID: 29151048.
- [74] Picetti E, Rossi S, Abu-Zidan FM, Ansaloni L, Armonda R, Baiocchi GL, *et al*. WSES consensus conference guidelines: monitoring and management of severe adult traumatic brain injury patients with polytrauma in the first 24 hours. *World J Emerg Surg* 2019;14:53. DOI: 10.1186/s13017-019-0270-1, PMID: 31798673.
- [75] Brower RG, Matthay MA, Morris A, Schoenfeld D, Thompson BT, Wheeler A, Acute Respiratory Distress Syndrome Network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. *N Engl J Med* 2000;342(18):1301–1308. DOI: 10.1056/NEJM200005043421801, PMID: 10793162.
- [76] Robba C, Poole D, McNett M, Asehnoune K, Bösel J, Bruder N, *et al*. Mechanical ventilation in patients with acute brain injury: recommendations of the European Society of Intensive Care Medicine consensus. *Intensive Care Med* 2020;46(12):2397–2410. DOI: 10.1007/s00134-020-06283-0, PMID: 33175276.
- [77] Anderson D, Chen SA, Godoy LA, Brown LM, Cooke DT. Comprehensive Review of Chest Tube Management: A Review. *JAMA Surg* 2022;157(3):269–274. DOI: 10.1001/jamasurg.2021.7050, PMID: 35080596.
- [78] Kasotakis G, Sideris A, Yang Y, de Moya M, Alam H, King DR, *et al*. Aggressive early crystalloid resuscitation adversely affects outcomes in adult blunt trauma patients: an analysis of the Glue Grant database. *J Trauma Acute Care Surg* 2013;74(5):1215–21; discussion 1221. DOI: 10.1097/TA.0b013e3182826e13, PMID: 23609270.
- [79] LaGrone LN, Stein D, Cribari C, Kaups K, Harris C, Miller AN, *et al*. American Association for the Surgery of Trauma/American College of Surgeons Committee on Trauma: Clinical protocol for damage-control resuscitation for the adult trauma patient. *J Trauma Acute Care Surg* 2024;96(3):510–520. DOI: 10.1097/TA.00000000000004088, PMID: 37697470.
- [80] Baird EW, Lammers DT, Griffin RL, Stephens SW, Jansen JO, Holcomb JB. Is Mechanism a Biological Variable?: A Secondary Analysis of the PROPPR Trial. *Ann Surg Open* 2025;6(2):e572. DOI: 10.1097/AS9.0000000000000572, PMID: 40557349.
- [81] Wiedemann HP, Wheeler AP, Bernard GR, Thompson BT, Hayden D, deBoisblanc B, *et al*. Comparison of two fluid-management strategies in acute lung injury. *N Engl J Med* 2006;354(24): 2564–2575. DOI: 10.1056/NEJMoa062200, PMID: 16714767.
- [82] Chacko J, Chalfin DB, Seppelt I, Pawar S, Brar G. Conservative vs. Liberal Fluid Management in ARDS: The FACTT Trial. In: *Landmark Studies in Critical Care*. Singapore: Springer; 2025;121–128. DOI: 10.1007/978-981-95-0673-6_16.
- [83] Mendes RS, Pelosi P, Schultz MJ, Rocco PRM, Silva PL. Fluids in ARDS: more pros than cons. *Intensive Care Med Exp* 2020;8(Suppl 1):32. DOI: 10.1186/s40635-020-00319-x, PMID: 33336259.
- [84] ATLS Subcommittee; American College of Surgeons' Committee on Trauma; International ATLS working group. Advanced trauma life support (ATLS®): the ninth edition. *J Trauma Acute Care Surg* 2013; 74(5):1363–1366. DOI: 10.1097/TA.0b013e31828b82f5, PMID: 23609291.
- [85] Voller J, Tobin JM, Cap AP, Cunningham CW, Denoyer M, Drew B, *et al*. Joint Trauma System Clinical Practice Guideline (JTS CPG): Prehospital Blood Transfusion. 30 October 2020. *J Spec Oper Med* 2021;21(4):11–21. DOI: 10.55460/P685-L7R7, PMID: 34969121.
- [86] Tran A, Fernando SM, Brochard LJ, Fan E, Inaba K, Ferguson ND, *et al*. Prognostic factors for development of acute respiratory distress syndrome following traumatic injury: a systematic review and meta-analysis. *Eur Respir J* 2022;59(4):2100857. DOI: 10.1183/13993003.00857-2021, PMID: 34625477.
- [87] Jansen JO, Hudson J, Cochran C, MacLennan G, Lendrum R, Sadek S, *et al*. Emergency Department Resuscitative Endovascular Balloon Occlusion of the Aorta in Trauma Patients With Exsanguinating Hemorrhage: The UK-REBOA Randomized Clinical Trial. *JAMA* 2023;330(19):1862–1871. DOI: 10.1001/jama.2023.20850, PMID: 37824132.
- [88] Harfouche MN, Bugaev N, Como JJ, Fraser DR, McNickle AG, Golani G, *et al*. Resuscitative Endovascular Balloon Occlusion of the Aorta in surgical and trauma patients: a systematic review, meta-analysis and practice management guideline from the Eastern Association for the Surgery of Trauma. *Trauma Surg Acute Care Open* 2025; 10(1):e001730. DOI: 10.1136/tsaco-2024-001730, PMID: 40166770.
- [89] Fontenelle Ribeiro Junior MA, Salman SM, Al-Qaraghuli SM, Makki F, Abu Affan RA, Mohseni SR, *et al*. Complications associated with the use of resuscitative endovascular balloon occlusion of the aorta (REBOA): an updated review. *Trauma Surg Acute Care Open* 2024; 9(1):e001267. DOI: 10.1136/tsaco-2023-001267, PMID: 38347890.

- [90] Tullos A, Wunnava S, Medina D, Sheahan C, Chawla A, Torrance B, *et al*. Vascular complications secondary to resuscitative endovascular balloon occlusion of the aorta placement at a Level 1 Trauma Center. *J Vasc Surg* 2024;80(1):64–69. DOI: 10.1016/j.jvs.2024.03.020, PMID: 38493898.
- [91] Hoshi H, Endo A, Yamamoto R, Yamakawa K, Suzuki K, Akutsu T, *et al*. Use of resuscitative endovascular balloon occlusion of the aorta (REBOA) for trauma and its performance in Japan over the past 18 years: a nationwide descriptive study. *World J Emerg Surg* 2024; 19(1):19. DOI: 10.1186/s13017-024-00548-5, PMID: 38822409.
- [92] Kataoka Y, Minehara H, Kashimi F, Hanajima T, Yamaya T, Nishimaki H, *et al*. Hybrid treatment combining emergency surgery and intraoperative interventional radiology for severe trauma. *Injury* 2016;47(1):59–63. DOI: 10.1016/j.injury.2015.09.022, PMID: 26508437.
- [93] Moore JM, Thomas PA, Gruen RL, Chan P, Rosenfeld JV. Simultaneous multisystem surgery: An important capability for the civilian trauma hospital. *Clin Neurol Neurosurg* 2016;148:13–16. DOI: 10.1016/j.clineuro.2016.06.012, PMID: 27359088.
- [94] Wada D, Hayakawa K, Saito F, Yoshiya K, Nakamori Y, Kuwagata Y. Combined brain and thoracic trauma surgery in a hybrid emergency room system: a case report. *BMC Surg* 2021;21(1):219. DOI: 10.1186/s12893-021-01218-y, PMID: 33906660.
- [95] Bunya N, Harada K, Kuroda Y, Toyohara T, Toyohara T, Kubota N, *et al*. The effectiveness of hybrid treatment for severe multiple trauma: a case of multiple trauma for damage control laparotomy and thoracic endovascular repair. *Int J Emerg Med* 2017;10(1):18. DOI: 10.1186/s12245-017-0145-8, PMID: 28585119.
- [96] Sato K, Tamura Y, Shibuya H, Sano T, Takahashi K. Simultaneously operation for combined head and abdominal blunt trauma: A case report. *Trauma Case Rep* 2023;46:100841. DOI: 10.1016/j.tcr.2023.100841, PMID: 37234085.
- [97] Cook AM, Morgan Jones G, Hawryluk GWJ, Mailloux P, McLaughlin D, Papangelou A, *et al*. Guidelines for the Acute Treatment of Cerebral Edema in Neurocritical Care Patients. *Neurocrit Care* 2020; 32(3):647–666. DOI: 10.1007/s12028-020-00959-7, PMID: 32227294.
- [98] Roberts I, Yates D, Sandercock P, Farrell B, Wasserberg J, Lomas G, *et al*. Effect of intravenous corticosteroids on death within 14 days in 10008 adults with clinically significant head injury (MRC CRASH trial): randomised placebo-controlled trial. *Lancet* 2004;364(9442): 1321–1328. DOI: 10.1016/S0140-6736(04)17188-2, PMID: 15474134.
- [99] Amer M, Alshahrani MS, Arabi YM, Al-Jedai A, Alshaqqaq HM, Al-Sharydah A, *et al*. Saudi Critical Care Society clinical practice guidelines on the prevention of venous thromboembolism in adults with trauma: reviewed for evidence-based integrity and endorsed by the Scandinavian Society of Anaesthesiology and Intensive Care Medicine. *Ann Intensive Care* 2023;13(1):41. DOI: 10.1186/s13613-023-01135-8, PMID: 37165105.
- [100] Ratnasekera A, Geerts W, Haut ER, Price M, Costantini T, Murphy P. Implementation science approaches to optimizing venous thromboembolism prevention in patients with traumatic injuries: Findings from the 2022 Consensus Conference to Implement Optimal Venous Thromboembolism Prophylaxis in Trauma. *J Trauma Acute Care Surg* 2023;94(3):490–494. DOI: 10.1097/TA.0000000000003850, PMID: 36729882.
- [101] Ley EJ, Brown CVR, Moore EE, Sava JA, Peck K, Ciesla DJ, *et al*. Updated guidelines to reduce venous thromboembolism in trauma patients: A Western Trauma Association critical decisions algorithm. *J Trauma Acute Care Surg* 2020;89(5):971–981. DOI: 10.1097/TA.0000000000002830, PMID: 32590563.
- [102] Nyquist P, Bautista C, Jichici D, Burns J, Chhangani S, DeFilippis M, *et al*. Prophylaxis of Venous Thrombosis in Neurocritical Care Patients: An Evidence-Based Guideline: A Statement for Healthcare Professionals from the Neurocritical Care Society. *Neurocrit Care* 2016;24(1):47–60. DOI: 10.1007/s12028-015-0221-y, PMID: 26646118.
- [103] Al-Dorzi HM, Al-Yami G, Al-Daker F, Alqirnas MQ, Alhamadh MS, Khan R. The association of timing of pharmacological prophylaxis and venous thromboembolism in patients with moderate-to-severe traumatic brain injury: A retrospective cohort study. *Ann Thorac Med* 2022;17(2):102–109. DOI: 10.4103/atm.atm_174_21, PMID: 35651893.
- [104] Byrne JP, Witiw CD, Schuster JM, Pascual JL, Cannon JW, Martin ND, *et al*. Association of Venous Thromboembolism Prophylaxis After Neurosurgical Intervention for Traumatic Brain Injury With Thromboembolic Complications, Repeated Neurosurgery, and Mortality. *JAMA Surg* 2022;157(3):e215794. DOI: 10.1001/jamasurg.2021.5794, PMID: 34910096.
- [105] Ratnasekera AM, Kim D, Seng SS, Jacovides C, Kaufman EJ, Sadek HM, *et al*. Early VTE prophylaxis in severe traumatic brain injury: A propensity score weighted EAST multicenter study. *J Trauma Acute Care Surg* 2023;95(1):94–104. DOI: 10.1097/TA.0000000000003985, PMID: 37017458.
- [106] Al Tannir AH, Biesboer EA, Tentis M, Golestani S, Dodgion C, Peschman JR, *et al*. Evaluating the efficacy and safety of low-molecular weight heparin as a chemoprophylactic agent in stable traumatic brain injury. *Am J Surg* 2025;246:116389. DOI: 10.1016/j.amjsurg.2025.116389, PMID: 40378495.
- [107] Elkbuli A, Watts E, Patel H, Chin B, Wright DD, Inouye M, *et al*. National Analysis of Outcomes for Adult Trauma Patients With Isolated Severe Blunt Traumatic Brain Injury Following Venous Thromboembolism Prophylaxis. *J Surg Res* 2024;300:165–172. DOI: 10.1016/j.jss.2024.04.075, PMID: 38815515.
- [108] Yorkgitis BK, Berndtson AE, Cross A, Kennedy R, Kochuba MP, Tignanelli C, *et al*. American Association for the Surgery of Trauma/ American College of Surgeons-Committee on Trauma Clinical Protocol for inpatient venous thromboembolism prophylaxis after trauma. *J Trauma Acute Care Surg* 2022;92(3):597–604. DOI: 10.1097/TA.0000000000003475, PMID: 34797813.
- [109] Schellenberg M, Costantini T, Joseph B, Price MA, Bernard AC, Haut ER. Timing of venous thromboembolism prophylaxis initiation after injury: Findings from the consensus conference to implement optimal VTE prophylaxis in trauma. *J Trauma Acute Care Surg* 2023; 94(3):484–489. DOI: 10.1097/TA.0000000000003847, PMID: 36729602.
- [110] Frontera JA, Gilmore EJ, Johnson EL, Olson D, Rayi A, Tesoro E, *et al*. Guidelines for Seizure Prophylaxis in Adults Hospitalized with Moderate-Severe Traumatic Brain Injury: A Clinical Practice Guideline for Health Care Professionals from the Neurocritical Care Society. *Neurocrit Care* 2024;40(3):819–844. DOI: 10.1007/s12028-023-01907-x, PMID: 38316735.
- [111] Chang BS, Lowenstein DH; Quality Standards Subcommittee of the American Academy of Neurology. Practice parameter: antiepileptic drug prophylaxis in severe traumatic brain injury: report of the Quality Standards Subcommittee of the American Academy of Neurology. *Neurology* 2003;60(1):10–16. DOI: 10.1212/01.wnl.0000031432.05543.14, PMID: 12525711.

- [112] Coelho LMG, Blacker D, Hsu J, Newhouse JP, Westover MB, Zafar SF, *et al*. Association of Early Seizure Prophylaxis With Posttraumatic Seizures and Mortality: A Meta-analysis With Evidence Quality Assessment. *Neurol Clin Pract* 2023;13(3):e200145. DOI: 10.1212/CPJ.0000000000200145, PMID: 37066107.
- [113] Kumar S, Bharti AK, Prasad RS, Kumari S, Singh A, Yadav G. Efficacy of phenytoin for 7 days versus 21 days as prophylactic anticonvulsant in traumatic brain injury patients - A comparative study. *J Family Med Prim Care* 2022;11(8):4805–4810. DOI: 10.4103/jfmpc.jfmpc_486_22, PMID: 36353001.
- [114] Jones KE, Puccio AM, Harshman KJ, Falcione B, Benedict N, Jankowitz BT, *et al*. Levetiracetam versus phenytoin for seizure prophylaxis in severe traumatic brain injury. *Neurosurg Focus* 2008;25(4):E3. DOI: 10.3171/FOC.2008.25.10.E3, PMID: 18828701.
- [115] Karamian A, Farzaneh H, Taheri M, Seifi A. Effectiveness of Levetiracetam versus phenytoin in preventing seizure in traumatic brain injury patients: A systematic review and meta-analysis. *Clin Neurol Neurosurg* 2024;240:108251. DOI: 10.1016/j.clineuro.2024.108251, PMID: 38569246.
- [116] Herman ST, Abend NS, Bleck TP, Chapman KE, Drislane FW, Emerson RG, *et al*. Consensus statement on continuous EEG in critically ill adults and children, part I: indications. *J Clin Neurophysiol* 2015;32(2):87–95. DOI: 10.1097/WNP.000000000000166, PMID: 25626778.
- [117] Kwon SJ, Barletta JF, Hall ST, Mangram AJ, Dzandu JK, Abdulhamid M, *et al*. Lacosamide versus phenytoin for the prevention of early post traumatic seizures. *J Crit Care* 2019;50:50–53. DOI: 10.1016/j.jcrc.2018.11.010, PMID: 30471561.
- [118] Angriman F, Taran S, Angeloni N, Devion C, Lee JW, Adhikari NKJ. Antiseizure Medications in Adult Patients With Traumatic Brain Injury: A Systematic Review and Bayesian Network Meta-Analysis. *Crit Care Explor* 2024;6(10):e1160. DOI: 10.1097/CCE.0000000000001160, PMID: 39324956.
- [119] National Institute for Health and Care Excellence: Guidelines. Rehabilitation after traumatic injury. London: National Institute for Health and Care Excellence (NICE); 2022.
- [120] Turner-Stokes L, Pick A, Nair A, Disler PB, Wade DT. Multidisciplinary rehabilitation for acquired brain injury in adults of working age. *Cochrane Database Syst Rev* 2015;2015(12):CD004170. DOI: 10.1002/14651858.CD004170.pub3, PMID: 26694853.
- [121] Ichikawa T, Tsuchiya A, Tsutsumi Y, Okawa T, Kubo D, Horimizu Y, *et al*. Effect of a generalized early mobilization and rehabilitation protocol on outcomes in trauma patients admitted to the intensive care unit: a retrospective pre-post study. *Crit Care* 2025;29(1):337. DOI: 10.1186/s13054-025-05570-w, PMID: 40739567.
- [122] Nazwar TA, Triangto I, Pringga GA, Bal'afif F, Wardana DW. Mobilization phases in traumatic brain injury. *Acute Crit Care* 2023;38(3):261–270. DOI: 10.4266/acc.2023.00640, PMID: 37652856.
- [123] Yen HC, Chuang HJ, Hsiao WL, Tsai YC, Hsu PM, Chen WS, *et al*. Assessing the impact of early progressive mobilization on moderate-to-severe traumatic brain injury: a randomized controlled trial. *Crit Care* 2024;28(1):172. DOI: 10.1186/s13054-024-04940-0, PMID: 38778416.
- [124] Arzayus-Patiño L, Estela-Zape JL, Sanclemente-Cardoza V. Safety of Early Mobilization in Adult Neurocritical Patients: An Exploratory Review. *Crit Care Res Pract* 2025;2025:4660819. DOI: 10.1155/ccrp/4660819, PMID: 40041540.
- [125] American College of Surgeons Committee on Trauma. Advanced Trauma Life Support (ATLS) Student Course Manual. 11th ed. Chicago: American College of Surgeons; 2025.
- [126] Molnar TF. Thoracic Trauma: Which Chest Tube When and Where? *Thorac Surg Clin* 2017;27(1):13–23. DOI: 10.1016/j.thorsurg.2016.08.003, PMID: 27865322.
- [127] Coccolini F, Cremonini C, Moore EE, Civil I, Balogh Z, Leppaniemi A, *et al*. Liver trauma: WSES-AAST guidelines. *World J Emerg Surg* 2025;20(1):78. DOI: 10.1186/s13017-025-00651-1, PMID: 41094688.
- [128] Zeiler J, Idell S, Norwood S, Cook A. Hemothorax: A Review of the Literature. *Clin Pulm Med* 2020;27(1):1–12. DOI: 10.1097/CPM.0000000000000343, PMID: 33437141.
- [129] Coccolini F, Catena F, Moore EE, Ivatury R, Biffl W, Peitzman A, *et al*. WSES classification and guidelines for liver trauma. *World J Emerg Surg* 2016;11:50. DOI: 10.1186/s13017-016-0105-2, PMID: 27766112.
- [130] Coccolini F, Coimbra R, Ordonez C, Kluger Y, Vega F, Moore EE, *et al*. Liver trauma: WSES 2020 guidelines. *World J Emerg Surg* 2020;15(1):24. DOI: 10.1186/s13017-020-00302-7, PMID: 32228707.
- [131] Coccolini F, Stahel PF, Montori G, Biffl W, Horer TM, Catena F, *et al*. Pelvic trauma: WSES classification and guidelines. *World J Emerg Surg* 2017;12:5. DOI: 10.1186/s13017-017-0117-6, PMID: 28115984.
- [132] Bullock MR, Chesnut R, Ghajar J, Gordon D, Hartl R, Newell DW, *et al*. Surgical management of acute subdural hematomas. *Neurosurgery* 2006;58(3 Suppl):S16–S24; discussion Si. DOI: 10.1227/01.NEU.0000210364.29290.C9, PMID: 16710968.
- [133] Cooper DJ, Rosenfeld JV, Murray L, Arabi YM, Davies AR, D'Urso P, *et al*. Decompressive craniectomy in diffuse traumatic brain injury. *N Engl J Med* 2011;364(16):1493–1502. DOI: 10.1056/NEJMoa1102077, PMID: 21434843.
- [134] Hutchinson PJ, Kolias AG, Timofeev IS, Corteen EA, Czosnyka M, Timothy J, *et al*. Trial of Decompressive Craniectomy for Traumatic Intracranial Hypertension. *N Engl J Med* 2016;375(12):1119–1130. DOI: 10.1056/NEJMoa1605215, PMID: 27602507.
- [135] Mowery NT, Gunter OL, Collier BR, Diaz JJ Jr, Haut E, Hildreth A, *et al*. Practice management guidelines for management of hemothorax and occult pneumothorax. *J Trauma* 2011;70(2):510–518. DOI: 10.1097/TA.0b013e31820b5c31, PMID: 21307755.
- [136] Bertoglio P, Guerrero F, Viti A, Terzi AC, Ruffini E, Lyberis P, *et al*. Chest drain and thoracotomy for chest trauma. *J Thorac Dis* 2019;11(Suppl 2):S186–S191. DOI: 10.21037/jtd.2019.01.53, PMID: 30906584.
- [137] Pumarejo Gomez L, Tran VH. Hemothorax. Treasure Island (FL): StatPearls Publishing; 2023.
- [138] Wagner HJ, Goossen K, Hilbert-Carius P, Braunschweig R, Kildal D, Hinck D, *et al*. Endovascular management of haemorrhage and vascular lesions in patients with multiple and/or severe injuries: a systematic review and clinical practice guideline update. *Eur J Trauma Emerg Surg* 2025;51(1):22. DOI: 10.1007/s00068-024-02719-0, PMID: 39820621.
- [139] Tamburini N, Carriel N, Cavallero G, Molins L, Galeotti R, Guzmán R, *et al*. Technical results, clinical efficacy and predictors of outcome of intercostal arteries embolization for hemothorax: a two-institutions' experience. *J Thorac Dis* 2019;11(11):4693–4699. DOI: 10.21037/jtd.2019.10.27, PMID: 31903258.
- [140] Rösch RM. From diagnosis to therapy: the acute traumatic hemothorax- an orientation for young surgeons. *Innov Surg Sci* 2023;8(4):221–226. DOI: 10.1515/iss-2023-0062, PMID: 38510367.
- [141] Laan DV, Vu TDN, Thiels CA, Pandian TK, Schiller HJ, Murad MH, *et al*. Chest wall thickness and decompression failure: A systematic

- review and meta-analysis comparing anatomic locations in needle thoracostomy. *Injury* 2016;47(4):797–804. DOI: 10.1016/j.injury.2015.11.045, PMID: 26724173.
- [142] Sharrock MK, Shannon B, Garcia Gonzalez C, Clair TS, Mitra B, Noonan M, *et al*. Prehospital paramedic pleural decompression: A systematic review. *Injury* 2021;52(10):2778–2786. DOI: 10.1016/j.injury.2021.08.008, PMID: 34454722.
- [143] Seamon MJ, Haut ER, Van Arendonk K, Barbosa RR, Chiu WC, Dente CJ, *et al*. An evidence-based approach to patient selection for emergency department thoracotomy: A practice management guideline from the Eastern Association for the Surgery of Trauma. *J Trauma Acute Care Surg* 2015;79(1):159–173. DOI: 10.1097/TA.0000000000000648, PMID: 26091330.
- [144] Perkins ZB, Greenhalgh R, Ter Avest E, Aziz S, Whitehouse A, Read S, *et al*. Prehospital Resuscitative Thoracotomy for Traumatic Cardiac Arrest. *JAMA Surg* 2025;160(4):432–440. DOI: 10.1001/jamasurg.2024.7245, PMID: 40009367.
- [145] Roberts DJ, Bobrovitz N, Zygun DA, Kirkpatrick AW, Ball CG, Faris PD, *et al*. Evidence for use of damage control surgery and damage control interventions in civilian trauma patients: a systematic review. *World J Emerg Surg* 2021;16(1):10. DOI: 10.1186/s13017-021-00352-5, PMID: 33706763.
- [146] Roberts DJ, Bobrovitz N, Zygun DA, Ball CG, Kirkpatrick AW, Faris PD, *et al*. Indications for Use of Damage Control Surgery in Civilian Trauma Patients: A Content Analysis and Expert Appropriateness Rating Study. *Ann Surg* 2016;263(5):1018–1027. DOI: 10.1097/SLA.0000000000001347, PMID: 26445471.
- [147] Kinoshita T, Yamakawa K, Matsuda H, Yoshikawa Y, Wada D, Hamasaki T, *et al*. The Survival Benefit of a Novel Trauma Workflow that Includes Immediate Whole-body Computed Tomography, Surgery, and Interventional Radiology, All in One Trauma Resuscitation Room: A Retrospective Historical Control Study. *Ann Surg* 2019;269(2):370–376. DOI: 10.1097/SLA.00000000000002527, PMID: 28953551.
- [148] Ito K, Nagao T, Tsunoyama T, Kono K, Tomonaga A, Nakazawa K, *et al*. Hybrid emergency room system improves timeliness of angioembolization for pelvic fracture. *J Trauma Acute Care Surg* 2020;88(2):314–319. DOI: 10.1097/TA.00000000000002544, PMID: 31804417.
- [149] Kippnich M, Duempert M, Schorscher N, Jordan MC, Kunz AS, Meybohm P, *et al*. Simultaneous treatment of trauma patients in a dual room trauma suite with integrated movable sliding gantry CT system: an observational study. *Sci Rep* 2022;12(1):16065. DOI: 10.1038/s41598-022-20491-2, PMID: 36168030.
- [150] Picetti E, Rosenstein I, Balogh ZJ, Catena F, Taccone FS, Fornaciari A, *et al*. Perioperative Management of Polytrauma Patients with Severe Traumatic Brain Injury Undergoing Emergency Extracranial Surgery: A Narrative Review. *J Clin Med* 2021;11(1):18. DOI: 10.3390/jcm11010018, PMID: 35011760.
- [151] Kinoshita T, Moriwaki K, Hanaki N, Kitamura T, Yamakawa K, Fukuda T, *et al*. Cost-effectiveness of a hybrid emergency room system for severe trauma: a health technology assessment from the perspective of the third-party payer in Japan. *World J Emerg Surg* 2021;16(1):2. DOI: 10.1186/s13017-020-00344-x, PMID: 33413503.
- [152] Yun JH. Surgical outcomes in patients with simultaneous traumatic brain and torso injuries in a single regional trauma center over a 5-year period. *J Trauma Inj* 2021;34(4):270–278. DOI: 10.20408/jti.2021.0099.
- [153] Mubang RN, Smith MC, Guillaumondegui OD, Dennis BM. Lessons learned in multicavity polytrauma management. *ACS Case Reviews in Surgery* 2023;4(3):59–62.
- [154] Jacobs DG, Plaisier BR, Barie PS, Hammond JS, Holevar MR, Sinclair KE, *et al*. Practice management guidelines for geriatric trauma: the EAST Practice Management Guidelines Work Group. *J Trauma* 2003;54(2):391–416. DOI: 10.1097/01.TA.0000042015.54022.BE, PMID: 12579072.
- [155] Hung KK, Yeung JHH, Cheung CSK, Leung LY, Cheng RCH, Cheung NK, *et al*. Trauma team activation criteria and outcomes of geriatric trauma: 10 year single centre cohort study. *Am J Emerg Med* 2019;37(3):450–456. DOI: 10.1016/j.ajem.2018.06.011, PMID: 30041911.
- [156] Egodage T, Ho VP, Bongiovanni T, Knight-Davis J, Adams SD, Digiacomo J, *et al*. Geriatric trauma triage: optimizing systems for older adults-a publication of the American Association for the Surgery of Trauma Geriatric Trauma Committee. *Trauma Surg Acute Care Open* 2024;9(1):e001395. DOI: 10.1136/tsaco-2024-001395, PMID: 39021732.
- [157] Hasler RM, Nüesch E, Jüni P, Bouamra O, Exadaktylos AK, Lecky F. Systolic blood pressure below 110 mmHg is associated with increased mortality in penetrating major trauma patients: Multicentre cohort study. *Resuscitation* 2012;83(4):476–481. DOI: 10.1016/j.resuscitation.2011.10.018, PMID: 22056618.
- [158] Benhamed A, Batomen B, Boucher V, Yadav K, Isaac CJ, Mercier E, *et al*. Relationship between systolic blood pressure and mortality in older vs younger trauma patients - a retrospective multicentre observational study. *BMC Emerg Med* 2023;23(1):105. DOI: 10.1186/s12873-023-00863-1, PMID: 37726708.
- [159] Kragh JF Jr, Walters TJ, Baer DG, Fox CJ, Wade CE, Salinas J, *et al*. Practical use of emergency tourniquets to stop bleeding in major limb trauma. *J Trauma* 2008;64(2 Suppl):S38–49; discussion S49. DOI: 10.1097/TA.0b013e31816086b1, PMID: 18376170.
- [160] Eastridge BJ, Mabry RL, Seguin P, Cantrell J, Tops T, Uribe P, *et al*. Death on the battlefield (2001–2011): implications for the future of combat casualty care. *J Trauma Acute Care Surg* 2012;73(6 Suppl 5):S431–S437. DOI: 10.1097/TA.0b013e3182755dcd, PMID: 23192066.
- [161] Welch M, Barratt J, Peters A, Wright C. Systematic review of prehospital haemostatic dressings. *BMJ Mil Health* 2020;166(3):194–200. DOI: 10.1136/jramc-2018-001066, PMID: 30711924.
- [162] Winstanley M, Smith JE, Wright C. Catastrophic haemorrhage in military major trauma patients: a retrospective database analysis of haemostatic agents used on the battlefield. *J R Army Med Corps* 2019;165(6):405–409. DOI: 10.1136/jramc-2018-001031, PMID: 30287682.
- [163] Deaton TG, Drew B, Montgomery HR, Butler FK Jr. Tactical Combat Casualty Care (TCCC) Guidelines: 25 January 2024. *J Spec Oper Med* 2024;24(1):100–108. DOI: 10.55460/QT3B-XK5B, PMID: 38364091.
- [164] Blackburne LH, Baer DG, Eastridge BJ, Kheirabadi B, Bagley S, Kragh JF Jr, *et al*. Military medical revolution: prehospital combat casualty care. *J Trauma Acute Care Surg* 2012;73(6 Suppl 5):S372–S377. DOI: 10.1097/TA.0b013e3182755662, PMID: 23192058.
- [165] Xing JY, Cao SY, Wang ZY, Lu B, Pan F, Song HN, *et al*. Hemostatic effect of zeolite-kaolin composite gauze in a porcine model of massive hemorrhage from explosive injury at the junctional sites (in Chinese). *Medical Journal of Chinese People's Liberation Army* 2026;51(1):78–85. DOI: 10.11855/j.issn.0577-7402.1795.2025.0826.
- [166] Steyerberg EW, Mushkudiani N, Perel P, Butcher I, Lu J, McHugh

- GS, *et al*. Predicting outcome after traumatic brain injury: development and international validation of prognostic scores based on admission characteristics. *PLoS Med* 2008;5(8):e165; discussion e165. DOI: 10.1371/journal.pmed.0050165, PMID: 18684008.
- [167] Perel P, Arango M, Clayton T, Edwards P, Komolafe E, Poccock S, *et al*. Predicting outcome after traumatic brain injury: practical prognostic models based on large cohort of international patients. *BMJ* 2008;336(7641):425–429. DOI: 10.1136/bmj.39461.643438.25, PMID: 18270239.
- [168] Carra G, Güiza F, Piper I, Citerio G, Maas A, Depreitere B, *et al*. Development and External Validation of a Machine Learning Model for the Early Prediction of Doses of Harmful Intracranial Pressure in Patients with Severe Traumatic Brain Injury. *J Neurotrauma* 2023; 40(5-6):514–522. DOI: 10.1089/neu.2022.0251, PMID: 35950615.
- [169] Tienpratarn W, Phinyo P, Yuxsen C, Wongwaisayawan S, Khorana J, Patumanond J. Domain validation of the CRASH prognostic model for predicting 14-day mortality among patients and traumatic brain injury and intracranial hemorrhage in a Thai emergency department. *Int J Emerg Med* 2025;18(1):202. DOI: 10.1186/s12245-025-01008-w, PMID: 41087867.
- [170] Abdullah JM, Idris Z, Ghani AR, Lim MS. Prediction of outcomes in traumatic brain injury: The IMPACT and CRASH prognostic models in a single neurosurgical center, Malaysia. *J Neurosurg Sci* 2023; 67(3):367–373. DOI: 10.23736/S0390-5616.21.05249-8, PMID: 33709663.
- [171] Camarano JG, Ratliff HT, Korst GS, Hrushka JM, Jupiter DC. Predicting in-hospital mortality after traumatic brain injury: External validation of CRASH-basic and IMPACT-core in the national trauma data bank. *Injury* 2021;52(2):147–153. DOI: 10.1016/j.injury.2020.10.051, PMID: 33070947.
- [172] Pease M, Arefan D, Hammond FM, Castellano JF, Okonkwo DO, Wu S. Computational Prognostic Modeling in Traumatic Brain Injury. *Adv Exp Med Biol* 2024;1462:475–486. DOI: 10.1007/978-3-031-64892-2_29, PMID: 39523284.
- [173] de Cássia Almeida Vieira R, Silveira JCP, Paiva WS, de Oliveira DV, de Souza CPE, Santana-Santos E, *et al*. Prognostic Models in Severe Traumatic Brain Injury: A Systematic Review and Meta-analysis. *Neurocrit Care* 2022;37(3):790–805. DOI: 10.1007/s12028-022-01547-7, PMID: 35941405.
- [174] Dijkland SA, Foks KA, Polinder S, Dippel DWJ, Maas AIR, Lingsma HF, *et al*. Prognosis in Moderate and Severe Traumatic Brain Injury: A Systematic Review of Contemporary Models and Validation Studies. *J Neurotrauma* 2020;37(1):1–13. DOI: 10.1089/neu.2019.6401, PMID: 31099301.
- [175] An T, Dong Z, Li X, Ma Y, Jin J, Li L, *et al*. Comparative analysis of CRASH and IMPACT in predicting the outcome of 340 patients with traumatic brain injury. *Transl Neurosci* 2024;15(1):20220327. DOI: 10.1515/tnsci-2022-0327, PMID: 38529016.
- [176] Roozenbeek B, Lingsma HF, Lecky FE, Lu J, Weir J, Butcher I, *et al*. Prediction of outcome after moderate and severe traumatic brain injury: external validation of the International Mission on Prognosis and Analysis of Clinical Trials (IMPACT) and Corticoid Randomisation After Significant Head injury (CRASH) prognostic models. *Crit Care Med* 2012;40(5):1609–1617. DOI: 10.1097/CCM.0b013e31824519ce, PMID: 22511138.
- [177] Yue JK, Lee YM, Sun X, van Essen TA, Elguindy MM, Belton PJ, *et al*. Performance of the IMPACT and CRASH prognostic models for traumatic brain injury in a contemporary multicenter cohort: a TRACK-TBI study. *J Neurosurg* 2024;141(2):417–429. DOI: 10.3171/2023.11.JNS231425, PMID: 38489823.
- [178] Han J, King NK, Neilson SJ, Gandhi MP, Ng I. External validation of the CRASH and IMPACT prognostic models in severe traumatic brain injury. *J Neurotrauma* 2014;31(13):1146–1152. DOI: 10.1089/neu.2013.3003, PMID: 24568201.
- [179] Maas AIR, Menon DK, Manley GT, Abrams M, Åkerlund C, Andelic N, *et al*. Traumatic brain injury: progress and challenges in prevention, clinical care, and research. *Lancet Neurol* 2022;21(11):1004–1060. DOI: 10.1016/S1474-4422(22)00309-X, PMID: 36183712.
- [180] Takegami N, Torres-Espin A, Imagawa Y, Watanabe I, Rowell S, Schreiber M, *et al*. Evaluating and Updating the IMPACT Model to Predict Outcomes in Two Contemporary North American Traumatic Brain Injury Cohorts. *J Neurotrauma* 2025;42(17-18): 1585–1600. DOI: 10.1089/neu.2024.0158, PMID: 38984940.
- [181] Wongchareon K, Thompson HJ, Mitchell PH, Barber J, Temkin N. IMPACT and CRASH prognostic models for traumatic brain injury: external validation in a South-American cohort. *Inj Prev* 2020;26(6): 546–554. DOI: 10.1136/injuryprev-2019-043466, PMID: 31959626.
- [182] Egea-Guerrero JJ, Rodríguez-Rodríguez A, Gordillo-Escobar E, Fernández-Delgado E, Martínez-Roldán Á, Roldán-Reina Á, *et al*. IMPACT Score for Traumatic Brain Injury: Validation of the Prognostic Tool in a Spanish Cohort. *J Head Trauma Rehabil* 2018; 33(1):46–52. DOI: 10.1097/HTR.0000000000000292, PMID: 28195955.
- [183] Dijkland SA, Helmrich IRAR, Nieboer D, van der Jagt M, Dippel DWJ, Menon DK, *et al*. Outcome Prediction after Moderate and Severe Traumatic Brain Injury: External Validation of Two Established Prognostic Models in 1742 European Patients. *J Neurotrauma* 2021;38(10):1377–1388. DOI: 10.1089/neu.2020.7300, PMID: 33161840.
- [184] Chen L, Xu H, He J, Zhang C, Maas AIR, Nieboer D, *et al*. Performance of the IMPACT and Helsinki models for predicting 6-month outcomes in a cohort of patients with traumatic brain injury undergoing cranial surgery. *Front Neurol* 2022;13:1031865. DOI: 10.3389/fneur.2022.1031865, PMID: 36388221.
- [185] Han JX, See AAQ, Gandhi M, King NKK. Models of Mortality and Morbidity in Severe Traumatic Brain Injury: An Analysis of a Singapore Neurotrauma Database. *World Neurosurg* 2017;108: 885–893.e1. DOI: 10.1016/j.wneu.2017.08.147, PMID: 28867312.
- [186] Collins GS, Moons KGM, Dhiman P, Riley RD, Beam AL, Van Calster B, *et al*. TRIPOD+AI statement: updated guidance for reporting clinical prediction models that use regression or machine learning methods. *BMJ* 2024;385:e078378. DOI: 10.1136/bmj-2023-078378, PMID: 38626948.

This article is an authorized English-language secondary publication based on the original Chinese guideline first published in the *Medical Journal of Chinese People's Liberation Army*, 2026;51(3):309–333, doi: 10.11855/j.issn.0577-7402.0142.2026.0308. Publication of this English version has been approved by the original publisher.