

# EGYPTIAN NATIONAL GUIDELINES FOR THE MANAGEMENT OF MASSIVE BLEEDING IN POLYTRAUMA PATIENTS

## Acknowledgement

### Chairperson of the Guideline Development Group (GDG):

- **Prof. Dr. Jehan Ali ElKholly**, Head of Scientific Committee of the Egyptian Board of the Emergency Medicine. Head of Anaesthesia, SICU & Pain Management Cairo University. Provided overall supervision and coordination of the guideline development process. Conducted comprehensive revision of the introduction and all recommendations

### Members of the Guideline Development Group (GDG):

- **Prof. Dr. Jehan Ali ElKholly**, Head of Scientific Committee of the Egyptian Board of the Emergency Medicine. Head of Anaesthesia, SICU & Pain Management Cairo University.
- **Prof. Dr. Maha Mohamed Ismail Youssef**  
Professor of anaesthesia, Surgical ICU, and Pain Management, Faculty of medicine, Cairo University *(GLN 5,6, 15,16,21,23, references distribution and revision)*
- **Dr. Ahmed Abouelyazeid Aly Abouelyazeid**  
Consultant of Emergency medicine and Traumatology, Director of Planning at Central Administration for Training; Egyptian Ambulance Organization, Chapter director of International Trauma Life Support ITLS at EAO. *(GLN 9,10)*
- **Dr. Omar Mohamed Mattar**  
Assistant lecturer of Emergency Medicine, Faculty of Medicine, Cairo University  
*(GLN 24)*

- **Heba Ali Abdelaziz Eldash**

Methodologist, Head of clinical pharmacy department in Banha Teaching Hospital (*Final revision and format editing*)

- **Dr. Ahmad Majed Abdul Mohsen Abdulaziz Younis**

Assistant lecturer of Emergency Medicine & Traumatology, Faculty of Medicine, Mansoura University (*introduction, GLN 1,2*)

- **Dr. Ahmed Mounir Sorour**

Emergency Officer / Public Health & Disaster Medicine Specialist, World Health Organization in Egypt (*GLN 3,4*)

- **Dr. Bassel Adel Elkhoully**

Assistant Lecturer of Emergency Medicine, Faculty of Medicine, Cairo University (*GLN 7,8*)

- **Dr. Eman Mohamed Gaber**

Emergency Medicine consultant - Deputy Manager of Critical and Urgent Care Administration, Alexandria Health Directorate (*GLN 11, 12*)

- **Dr. Fatma Abdelsalam Abdalla Ali**

Lecturer of Emergency Medicine & Traumatology, Faculty of Medicine, Tanta University (*GLN 13, 14*)

- **Dr. Mohamed Elsayed Elsherbiny**

Emergency medicine consultant, Chief of Training central administration, Egyptian Ambulance Organization (*GLN 17, 18*)

- **Dr. Mohamed Rashad Abdelaziz**

Emergency and disaster medicine consultant, International Federation for red cross and red crescent (*GLN 19, 20*)

- **Dr. Mostafa Abdelnaby**

Assistant lecturer of Anaesthesia, surgical ICU, and pain management, Faculty of medicine, Cairo University (*GLN 22*)

- **Dr. Omar Nasr**

Emergency Medicine Consultant -Head of the Emergency Department, Central Administration of Emergency & Critical Care – MOHP

- **Dr. Sally Wassfi**

Lecturer of Emergency Medicine, Faculty of Medicine, Alexandria University, ERC course director and educator (GLN 26)

- **Dr. Shaimaa El Sayed Mohamed**

Clinical pathology, Infection control consultant, National methodologist (GLN 27)

- **Dr. Noha Ahmed**

Manager of Critical and Urgent Care administration Alexandria Health Affairs Directorate, Neonatology consultant (GLN 28)

- **Dr A'laa Atef Shalaby**

Critical Care and Healthcare Quality Assurance Specialist - Central Administration of Emergency and Critical care - MOHP

- **Ph. Heba Abdelkader Hussein**

Methodologist - Pharmacy department manager in Mataria Teaching Hospital, GOTHI

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- **Prof. Dr. Jehan Ali ElKholy**
- **Prof. Dr. Maha Mohamed Ismail Youssef**

*Coordinators & Editing Supervisors*

1. **Prof. Dr. Maha Mohamed Ismail Youssef**
2. **Dr. Ahmed Abouelyazeid Aly Abouelyazeid**
3. **Dr. Omar Mohamed Mattar**

*Cover Designed & Edited By*

-Mr.

## Abbreviations

**ABCDE Approach:** Airway, Breathing, Circulation, Disability and Exposure approach

**ACS:** Acute Coronary Syndrome

**aPTT:** Activated Partial Thromboplastin Time

**ATLS:** Advanced Trauma Life Support

**AUROC:** Area Under the Receiver Operating Characteristics

**CCT:** Conventional coagulation tests

**DCR:** Damage Control Resuscitation

**eFAST:** extended Focused Assessment with Sonography for Trauma

**EHC:** Egyptian Health Council

**GCS:** Glasgow Coma Scale

**GDG:** Guideline Development Group

**GRADE:** Grading of Recommendations, Assessment, Development and Evaluation

**HES:** Hydroxyethyl Starches

**ICD-11:** International Classification of Diseases, 11th Edition

**INR:** International Normalized ratio

**MOHP:** the Ministry of Health and Population

**MT:** massive transfusion

**NGOs:** Non-Governmental Organizations

**PCC:** Prothrombin Complex Concentrate

**POCUS:** Point-of-Care Ultrasonography

**PP:** Pulse Pressure

**PT:** Prothrombin Time

**ROTEM:** Rotational Thromboelastometry

**SBP:** Systolic Blood Pressure

**SI:** Shock Index

**TACO:** Transfusion-Associated Circulatory Overload

**TBI:** Traumatic Brain Injury

**TEG:** Thromboelastography

**TIC:** Trauma-Induced Coagulopathy

**TXA:** Tranexamic Acid

**VHAs:** Viscoelastic Haemostatic Assays

**VKA:** Vitamin K Antagonists

**WBCT:** Whole-Body Computed Tomography

**WHO:** World Health Organization.

## Glossary

**Damage Control Resuscitation (DCR):** It emphasizes Permissive hypotension until bleeding is controlled, Balanced blood-product transfusion (plasma, platelets, red cells), Restricted crystalloid use to avoid dilutional coagulopathy and Early correction of coagulopathy.

**Multidisciplinary Approach:** Integration of emergency medicine, surgery, anaesthesia, and intensive care teams to deliver coordinated haemostatic resuscitation tailored to patient physiology.

# Executive Summary

This guideline provides standardized, **evidence-based recommendations** for the recognition and management of **massive bleeding in trauma patients**.

## Key Principles

- **Early Recognition & Immediate Control:** Rapid identification of haemorrhage and prompt surgical or interventional bleeding control is essential.
- **Damage Control Resuscitation (DCR):** Adopted globally over the past decade, DCR emphasizes:
  - Permissive hypotension until bleeding is controlled.
  - Balanced blood-product transfusion (plasma, platelets, red cells).
  - Restricted crystalloid use to avoid dilutional coagulopathy.
  - Early correction of coagulopathy.
- **Multidisciplinary Approach:** Integration of emergency medicine, surgery, anaesthesia, and intensive care teams to deliver coordinated haemostatic resuscitation tailored to patient physiology.

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## 1. Minimize Time to Bleeding Control

We recommend that the time between injury and bleeding control be minimized. **(Strong recommendation)**

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## 2. Local Compression of Open Wounds

We recommend local compression of open wounds to limit life-threatening bleeding. **(Strong recommendation)**

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## 3. Tourniquet Use for Extremity Injuries

We recommend adjunct tourniquet use to stop life-threatening bleeding from open extremity injuries in the pre-surgical setting. **(Strong recommendation)**

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## 4. Follow the C-ABCDE Approach

We recommend Following the C-ABCDE approach in the management of polytraumatized patients with massive bleeding. **(Strong recommendation)**

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## 5. Clinical Assessment of Traumatic Haemorrhage

We recommend that the physician should clinically assess the extent of traumatic hemorrhage using a combination of patient vital signs, anatomical injury pattern, mechanism of injury and the patient response to initial resuscitation. **(Strong recommendation)**

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## 6. Use of Shock Index (SI) and narrowed pulse pressure (PP)

We recommend that the Shock Index (SI) and/or Pulse Pressure (PP) be used to assess the degree of hypovolemic shock and transfusion requirements. **(Strong recommendation)**

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## 7. Immediate Bleeding Control

We recommend that patients with an obvious bleeding source and those presenting with haemorrhagic shock in extremities and a suspected source of bleeding undergo an immediate bleeding control procedure, if not available transfer patient to the nearest appropriate facility after stabilization. **(Strong recommendation)**

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## 8. Investigation of Unidentified Bleeding Source

We recommend that patients with an unidentified source of bleeding should undergo immediate further investigation to determine the bleeding source. **(Strong recommendation)**

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## 9. Use of Point-of-Care Ultrasonography (POCUS)

We suggest the use of point-of-care ultrasonography (POCUS), including eFAST, in patients with thoracoabdominal injuries if feasible **(Conditional recommendation)**

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## 10. Early Whole-Body CT (WBCT)

We suggest early imaging using contrast-enhanced whole-body CT (WBCT) for detection and identification of injury type and bleeding source after patient stabilization, if available. **(Conditional recommendation)**

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## 11. Repeated Haemoglobin/Haematocrit Monitoring

during resuscitation, we recommend repeating Hb and/or Hct measurements within 30 – 60 minutes, as initial normal values may mask early bleeding. **(Strong recommendation)**

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## **12. Lactate and Base Deficit Monitoring**

We suggest measurement of blood lactate as a sensitive test to estimate and monitor the extent of bleeding and tissue hypoperfusion; In the absence of lactate measurements, base deficit may represent a suitable alternative. If available. **(Conditional recommendation)**

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## **13. Monitoring of Haemostasis**

We recommend the early and repeated monitoring of haemostasis, using an international normalised ratio (INR), and platelet count. **(Strong recommendation)**

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## **14. Restricted Volume Replacement and Blood Pressure Targets**

We recommend the use of a restricted volume replacement strategy in the absence of clinical evidence of brain injury with a target systolic blood pressure of 80–90 mmHg (mean arterial pressure 50–60 mmHg) In the initial phase following trauma, until major bleeding has been stopped. **(Strong recommendation)**

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## **15. In patients with severe TBI (GCS $\leq$ 8)**

we recommend maintaining mean arterial pressure  $\geq$  80 mmHg. **(Strong recommendation)**

## **16. Use of Noradrenaline When Restricted Volume Replacement Fails**

we recommend the administration of **noradrenaline** to maintain target arterial blood pressure, if a restricted volume replacement strategy does not achieve the target blood pressure. **(Strong recommendation)**

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## **17. Choice of Crystalloid Solutions**

We recommend that fluid therapy using a 0.9% sodium chloride and/or ringer lactate or balanced crystalloid solution be initiated in the hypotensive bleeding trauma patient. **(Strong recommendation)**

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## **18. Avoidance of Hypotonic Solutions in TBI**

We recommend against **hypotonic solutions** during resuscitation of patients with haemorrhagic shock and traumatic brain injury. **(Strong recommendation)**

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### **19. Restriction of Colloid Use**

We suggest restricting the use of **colloids** due to their adverse effects on haemostasis. **(Conditional recommendation)**

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### **20. Target Haemoglobin After Bleeding Control**

We recommend a target haemoglobin of 7–9 g/dL after controlling the source of bleeding. **(Strong recommendation)**

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### **21. Prevention and Management of Hypothermia**

We recommend early application of measures such covering the patient and warm fluids to reduce heat loss and warm the hypothermic patient to achieve and maintain normothermia. **(Strong recommendation)**

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### **22. Damage Control Surgery**

We suggest damage control surgery in the severely injured patient if the definitive surgery to control the source of bleeding is complicated and time-consuming (>90 minutes) in the presence of severe persistent coagulopathy, severe acidosis with base deficit >15 mmol/L or lactate >5 mmol/L, hypothermia <34°C, or signs of ongoing bleeding despite the initial attempts of bleeding control with systolic BP persistently <90 mmHg. **(Conditional recommendation)**

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### **23. Pelvic Binder Use**

We recommend the adjunct use of a pelvic binder or pelvic sheet to limit life threatening bleeding in the presence of a suspected pelvic fracture. **(Strong recommendation)**

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### **24. Topical Haemostatic Agents**

We suggest the use of **topical haemostatic agents with packing** for venous or moderate arterial bleeding associated with parenchymal injuries. **(Conditional recommendation)**

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## **25. Tranexamic Acid (TXA)**

We recommend TXA administration in trauma patients who are bleeding or at risk of significant bleeding, as soon as possible and within 3 hours of injury at a loading dose of 1 g IV over 10 min, followed by 1 g IV infusion over 8 h. **(Strong recommendation)**

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## **26. Balanced Blood Product Transfusion**

We recommend transfusion of pRBCs: FFP: Platelets in ratio following the massive transfusion protocols, In the initial management of patients with suspected massive haemorrhage. **(Strong recommendation)**

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## **27. Calcium Monitoring and Supplementation**

We recommend that ionised calcium levels be monitored and maintained within the normal range following major trauma and especially during massive transfusion. We recommend the administration of calcium to correct hypocalcaemia. **(Strong recommendation)**

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## **28. Reversal of Vitamin K Antagonists (VKA)**

We recommend the emergency reversal of vitamin K-dependent oral anticoagulants in the bleeding trauma patient with the early use of 5–10 mg I.V. phytomenadione (vitamin K1) in addition to FFP. **(Strong recommendation)**

## Introduction

### The Global and National Challenge

Massive hemorrhage remains the primary cause of preventable mortality in polytrauma patients, presenting a formidable challenge to healthcare systems both globally and within Egypt. The clinical progression from uncontrolled bleeding to hypovolemic shock, coagulopathy, and multi-organ failure occurs with high velocity, necessitating immediate recognition and definitive intervention.

Central to the pathophysiology of traumatic death is the "**lethal triad**"—the synergistic effect of hypothermia, metabolic acidosis, and coagulopathy. These factors are the key determinants of survival during the critical "golden hour" of resuscitation, and their mitigation is the primary goal of early trauma care [1, 2].

### Evolution of Trauma Care: Damage Control Resuscitation

Over the last decade, the management of major haemorrhage has shifted toward **Damage Control Resuscitation (DCR)**. This evidence-based multidisciplinary approach prioritizes:

- **Permissive Hypotension:** Maintaining limited perfusion until surgical control is achieved.
- **Balanced Transfusion:** Utilizing fixed-ratio blood product administration (e.g., 1:1:1 pRBC, plasma, and platelets) to mimic whole blood [3].
- **Restricted Crystalloids:** Minimizing the use of clear fluids to avoid dilutional coagulopathy and tissue oedema [4, 5].

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## Scope and Purpose

Egypt faces a high trauma burden, placing emergency physicians at the forefront of haemorrhage management. This chapter provides standardized, evidence-based recommendations for the recognition and management of massive bleeding in trauma patients to be used by policymakers, health professionals, and emergency health care providers to offer better treatment strategies.

The objective of this chapter is to standardize practice to decrease variation of practice and improve outcomes for management of massive bleeding in trauma patients.

### Strategic Objectives

- **Standardize clinical practice** across emergency departments and trauma centres.
- **Optimize resource utilization** by standardizing transfusion and resuscitation protocols.

- **Strengthen coordination** among multidisciplinary teams for rapid haemorrhage control.
- **Enhance quality, safety, and equity** of emergency medical care nationwide.
- **Reduce preventable trauma-related mortality** through evidence-informed practice.

## Impact

By institutionalizing an evidence-based approach to trauma resuscitation, this guideline contributes to Egypt's broader vision of improving emergency care systems, reducing mortality, and aligning national practice with international standards.

## Target Audience

This guideline targets emergency physicians, general practitioners, policy makers, as well as non-governmental organizations (NGOs) and other stakeholders to offer the most appropriate treatment guidelines for trauma patients with massive bleeding.

## Methodology

This national guideline was developed under the auspices of the **Egyptian Health Council (EHC)**, the **Ministry of Health and Population (MOHP)**, and the **World Health Organization (WHO) Egypt Country Office**. To ensure international standards of transparency and clinical rigor while maintaining local contextual relevance, the **GRADE-ADOLOPMENT** methodology was employed for the adaptation of global evidence into the Egyptian clinical landscape [6,7].

A comprehensive search for guidelines was undertaken to identify the most relevant guidelines to consider for adaptation.

Inclusion/ exclusion criteria were followed in the search and retrieval of guidelines to be adapted:

- Selecting only evidence-based guidelines (guidelines must include a report on systematic literature searches and explicit links between individual recommendations and their supporting evidence)
- Selecting only national and/or international guidelines
- Selecting peer-reviewed publications only
- Selecting guidelines written in the English language
- Excluding guidelines written by a single author, not on behalf of an organization, to be valid and comprehensive, a guideline ideally requires multidisciplinary input

- Excluding guidelines published without references, as the panel needs to know whether a thorough literature review was conducted and whether current evidence was used in the preparation of the recommendations

The following characteristics of the retrieved guidelines were summarized in:

- Developing organization/authors
- Date of publication, posting, and release
- Country/language of publication
- Date of posting and/or release
- Dates of the search used by the source guideline developers

All retrieved Guidelines were screened and appraised using AGREE II instrument ([www.agreetrust.org](http://www.agreetrust.org)) by at least three members. The panel decided on a cut-off point or ranked the guidelines (any guideline scoring above 50% on the rigor dimension was retained). The GDG decided to adapt the Guidelines for the management of conditions specifically related to stress by the WHO and the Guidelines of the International Society for the Study of Trauma and Dissociation (ISSTD). (2,6)

### **Evidence assessment**

According to WHO Handbook for Guidelines, we used the GRADE (Grading of Recommendations, Assessment, Development and Evaluation) approach to assess the quality of a body of evidence, develop and report recommendations. GRADE methods are used by WHO because they represent internationally agreed standards for making transparent recommendations. Detailed GRADE information is available on the following sites:

- GRADE working group: <https://www.gradeworkinggroup.org/>
- GRADE online training modules: <http://cebgrade.mcmaster.ca/>

Table 1 Quality and Significance of the four levels of evidence in GRADE:

Quality	Definition	Implications
High	The guideline development group is very confident that the true effect lies close to that of the estimate of the effect	Further research is very unlikely to change confidence in the estimate of effect
Moderate	The guideline development group is moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different	Further research is likely to have an important impact on confidence in the estimate of effect and may change the estimate
Low	Confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the true effect	Further research is very likely to have an important impact on confidence in the estimate of effect and is unlikely to change the estimate
Very low	The group has very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of the effect	Any estimate of effect is very uncertain

**Table 2 Factors that determine How to upgrade or downgrade the quality of evidence**

Downgrade in presence of	Upgrade in presence of
Study limitations -1 Serious limitations -2 Very serious limitations	Dose-response gradient +1 Evidence of a dose-response gradient
Consistency -1 Important inconsistency	Direction of plausible bias +1 All plausible confounders would have reduced the effect
Directness -1 Some uncertainty -2 Major uncertainty	Magnitude of the effect +1 Strong, no plausible confounders, consistent and direct evidence
Precision -1 Imprecise data	+2 Very strong, no major threats to validity and direct evidence
Reporting bias -1 High probability of reporting bias	

### The strength of the recommendation

The strength of a recommendation communicates the importance of adherence to the recommendation.

### **Strong recommendations**

With strong recommendations, the guideline communicates the message that the desirable effects of adherence to the recommendation outweigh the undesirable effects. This means that in most situations the recommendation can be adopted as policy.

### **Conditional recommendations**

These are made when there is greater uncertainty about the four factors above or if local adaptation should account for a greater variety in values and preferences, or when resource use makes the intervention suitable for some, but not for other locations. This means that there is a need for substantial debate and involvement of stakeholders before this recommendation can be adopted as policy.

### **When not to make recommendations**

When there is lack of evidence on the effectiveness of an intervention, it may be appropriate not to make a recommendation.

# Recommendations

## 1. Minimize Time to Bleeding Control

We recommend that the time between injury and bleeding control be minimized.

**Strength of recommendation:** Strong

**Level of evidence:** Moderate

**Rationale:**

## Trauma Systems and the Chronology of Care

### Regionalization and Trauma System Maturity

The implementation of regionalized trauma systems has fundamentally improved outcomes for severely injured patients globally. These systems utilize a tiered network of designated trauma centers (Levels I through IV) that collaborate with pre-hospital Emergency Medical Services (EMS). A meta-analysis of over 1.1 million patients confirmed that the establishment of such systems significantly reduces mortality, with survival rates continuing to climb as these systems mature and integrate quality improvement programs and trauma registries [8].

Evidence from multicenter cohort studies indicates that patients in hemorrhagic shock (SBP < 90 mmHg) have significantly higher survival rates when treated at **Level I Trauma Centers** compared to Level III or IV facilities [9].

This underscores the necessity of a systemized approach that matches patient acuity to the appropriate facility based on vital status, injury patterns, and available hospital resources.

### The Impact of Time on Survival

Uncontrolled hemorrhage is the leading cause of potentially preventable trauma deaths, with data suggesting that approximately **34.5%** of early hemorrhagic fatalities could be avoided through more rapid bleeding control [10].

### Pre-Hospital Time Factors

Time lost during the pre-hospital phase is directly linked to increased mortality. Extensive analyses of EMS data demonstrate that:

- **Penetrating Trauma:** Every additional minute of response time correlates with a **2% increase in mortality**, while every extra minute spent on the scene correlates with a **1% increase** [11, 12].
- **Hemodynamic Instability:** For unstable patients, particularly those with penetrating injuries, "scoop and run" strategies (minimizing scene time) are significantly more beneficial than prolonged on-scene stabilization [13].

- **Functional Outcomes:** Even in hemodynamically stable patients where mortality might not be immediately affected by time, longer pre-hospital durations are associated with an increased risk of poor long-term functional recovery [14].

In-Hospital Delay: "Door-to-Needle"

The mandate to minimize time-to-intervention extends beyond the hospital doors. For patients with ongoing hemorrhage, "door-to-intervention" time—whether for surgery or angioembolization is a critical survival factor [15, 16].

Delays in initiating these procedures are associated with worsened outcomes, reinforcing that both swift pre-hospital transport and streamlined in-hospital trauma protocols are essential to patient salvage.

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## 2. Local Compression of Open Wounds

We recommend local compression of open wounds to limit life-threatening bleeding.

**Strength of recommendation:** Strong

**Level of evidence:** Moderate

**Rationale:**

## Local Haemorrhage Control Techniques

In civilian trauma, most life-threatening hemorrhages resulting from open extremity injuries can be managed effectively through local compression. This is typically achieved via direct manual pressure or the application of specialized pressure dressings to the site of injury [17].

Additional compression to the source of bleeding can also be achieved for some penetrating injuries by Foley catheter inserting directly into the wound, initially described in bleeding penetrating neck injuries. [18].

Furthermore, the efficacy of external hemorrhage control in pre-hospital environments is significantly enhanced using compression bandages impregnated with or used in conjunction with topical hemostatic agents [19].

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## 3. Tourniquet Use for Extremity Injuries

We recommend adjunct tourniquet use to stop life-threatening bleeding from open extremity injuries in the pre-surgical setting.

**Strength of recommendation:** Strong

**Level of evidence:** Moderate

**Rationale:**

## Rationale for Tourniquet Application

In cases of catastrophic extremity trauma, such as traumatic amputations or deep penetrating injuries, manual direct pressure may be insufficient to achieve definitive hemostasis. For these life-threatening scenarios, the application of a tourniquet is a critical, life-saving intervention [19].

Originally validated in military medicine where it has saved numerous lives, the efficacy of tourniquets is now strongly supported by civilian data demonstrating a significant decrease in hemorrhage-related mortality [19–22].

While potential complications—such as nerve injury or localized tissue damage have been documented, these risks are statistically rare and are heavily outweighed by the immediate necessity of preventing exsanguination [23–25].

A tourniquet acts as a vital bridge, controlling the bleeding just long enough to get the patient to definitive surgical care." [19].

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### 4. Follow the C-ABCDE Approach

We recommend Following the C-ABCDE approach in the management of polytraumatized patients with massive bleeding.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

### The <C>ABCDE Paradigm

In the acute management of severe trauma, the most immediate threat to patient survival is exsanguination from catastrophic hemorrhage, which can lead to death within minutes. Consequently, the traditional "ABCDE" resuscitation sequence has been refined to the "<C>ABCDE" framework [26].

By prioritizing "<C>" (**Catastrophic External Hemorrhage**) at the start of the primary survey, clinicians are directed to achieve definitive bleeding control even before addressing airway management. This fundamental shift in trauma priority ensures that the most time-critical physiological threat is mitigated immediately, thereby enhancing the efficacy of subsequent resuscitation and stabilization efforts [26, 27].

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## 5. Clinical Assessment of Traumatic Haemorrhage

We recommend that the physician should clinically assess the extent of traumatic haemorrhage using a combination of patient vital signs, anatomical injury pattern, mechanism of injury and the patient response to initial resuscitation.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

### Assessment and Prediction of Traumatic Haemorrhage

#### Limitations of Traditional Assessment and Scoring Systems

Although the current **ATLS classification system** for hypovolemic shock incorporates physiological markers like base excess to estimate blood loss and transfusion requirements, its precision remains a subject of clinical debate [26, 27].

While numerous predictive models and clinical scores have been engineered to forecast hemorrhage, traumatic coagulopathy, or the necessity for Massive Transfusion (MT), their performance is inconsistent. Reported **Area Under the Receiver Operating Characteristics (AUROC)** values range widely from 0.73 to 0.95, and a lack of robust prospective validation has prevented any single tool from achieving universal clinical adoption [28].

A meta-analysis of 84 studies identified 35 distinct predictive variables, with systolic blood pressure (SBP), age, heart rate, and injury mechanism being the most frequently scrutinized [28].

However, methodological rigor varies; of the 47 multivariate models analyzed, only 21 adhered to the standard of 10 events per predictor. The most reliable variables identified across multiple models include:

- Mechanism of injury
- Systolic Blood Pressure (SBP) and Heart Rate
- Haemoglobin and Lactate levels
- **Focused Assessment with Sonography in Trauma (FAST)** findings [28].

#### The Role of Injury Mechanism and Critical Haemorrhage

Evaluating the mechanism of trauma is essential for accurate risk stratification. A fall exceeding the "critical height" of **6 meters (20 feet)** is strongly correlated with major internal injuries and significant blood loss [29].

Furthermore, patients who are physically trapped following an incident often present with time-critical injuries that demand immediate intervention due to the high probability of occult hemorrhage [30].

Other high-risk mechanisms include high-energy deceleration impacts and wounds from high-velocity projectiles. Notably, modern clinical shifts toward **low-volume resuscitation** and **permissive hypotension** have changed how practitioners interpret a patient's physiological response to fluid challenges, making traditional assessment even more complex.

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## 6. Use of Shock Index (SI) and narrowed pulse pressure (PP)

We recommend that the Shock Index (SI) and/or Pulse Pressure (PP) be used to assess the degree of hypovolemic shock and transfusion requirements.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

### Predictive Value of Physiological Ratios

#### Shock Index (SI)

The **Shock Index (SI)**, defined as the ratio of heart rate to systolic blood pressure, serves as a robust predictor of occult hemorrhage. While a normal SI in healthy adults it ranges from 0.5 to 0.7, retrospective data indicates that values between 0.9 and 1.0 are associated with a 25% requirement for Massive Transfusion (MT), a 14.7% need for surgical intervention, and a 6.2% requirement for interventional radiology [31].

Across various retrospective studies, thresholds between 0.8 and 1.0 have consistently predicted the need for MT, yielding **AUROC** values between 0.73 and 0.89 [32–35].

Prospective analysis of 1,402 patients suggested that an SI of 0.8 provides higher sensitivity than 0.9 [32].

Specifically, a cut-off of 0.81 demonstrated 85% sensitivity and a 98% negative predictive value for MT [36], while a threshold of 0.91 achieved 81% sensitivity and 87% specificity [35].

Even after adjusting for age, sex, and injury severity (ISS/GCS), the SI remains an independent predictor for mortality and transfusion requirements (OR 3.57) [36].

Notably, an SI of 1.0 has been shown to outperform the **ABC score** in predicting MT and is more effective than simple hypotension in identifying patients requiring emergency operative intervention [33, 37].

#### Pulse Pressure (PP)

A narrowed **Pulse Pressure (PP)** the difference between systolic and diastolic blood pressure is a recognized hallmark of Class II hemorrhage according to ATLS guidelines. Current

literature defines a narrow PP as less than 40 mmHg, or in some clinical contexts, less than 30 mmHg.

Evidence confirms that a narrowed PP is independently linked to an increased likelihood of requiring blood transfusions, resuscitative thoracotomy, and emergent surgical control of bleeding [38–40].

Multivariate analyses further substantiate this, revealing that a PP below 30 mmHg is a significant predictor for both MT (OR 3.74) and the necessity for immediate operative intervention [41].

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## 7. Immediate Bleeding Control

We recommend that patients with an obvious bleeding source and those presenting with haemorrhagic shock in extremities and a suspected source of bleeding undergo an immediate bleeding control procedure, if not available transfer patient to the nearest appropriate facility after stabilization.

**Strength of recommendation:** Strong

**Level of evidence:** Moderate

**Rationale:**

### Rationale for Immediate Surgical Intervention

Patients presenting in profound hemorrhagic shock have typically sustained critical blood loss. In "agonal" patients where active hemorrhage persists, mortality is imminent unless the source of bleeding is controlled with extreme urgency.

Evidence from a study of 271 patients undergoing immediate laparotomy for gunshot wounds indicates that the combination of penetrating trauma and severe hypovolemic shock necessitates rapid, definitive surgical hemostasis [42].

Furthermore, a large-scale analysis of 16,113 trauma admissions identified a specific subset of 628 patients requiring "direct-to-operating-room" resuscitation. This study concluded that the most accurate predictors for the necessity of immediate surgical intervention include:

- **Mechanism of Injury:** Penetrating truncal trauma.
- **Anatomical/Physical Findings:** Traumatic amputations or other obvious major vascular disruptions.
- **Physiological Derangement:** Profound shock (systolic blood pressure < 90 mmHg) or a requirement for pre-hospital CPR [43].

Ultimately, for patients meeting these criteria, bypassing the traditional emergency department workup in favor of direct operative resuscitation optimizes outcomes when every minute is critical to survival [43].

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## 8. Investigation of Unidentified Bleeding Source

We recommend that patients with an unidentified source of bleeding should undergo immediate further investigation to determine the bleeding source.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

## Diagnostic Evaluation of the Stabilized Patient

For trauma patients who remain hemodynamically stable or achieve stabilization during initial resuscitation, a systematic diagnostic investigation is required to identify occult sources of hemorrhage. In cases where immediate surgical control is not indicated, the primary survey should be augmented with laboratory analysis—specifically blood gas and coagulation profiles and advanced imaging modalities, including ultrasonography and Computed Tomography (CT) [26, 44].

### The Evolution of Trauma Imaging

In modern trauma care, the widespread accessibility of CT scanners has largely superseded traditional radiographic imaging for the definitive assessment of internal injuries [45].

Research indicates that the physical proximity of the CT scanner to the resuscitation bay significantly improves survival probabilities for severely injured patients by minimizing transport times and delays in diagnosis [46].

### Whole-Body CT in Unstable Patients

When a CT scanner is located outside the emergency department, clinicians must carefully weigh the diagnostic benefits of imaging against the risks associated with transporting a critically ill patient. Continuous monitoring and ongoing resuscitation must be maintained throughout the transfer process. However, evidence suggests that within a well-structured environment and a highly organized trauma team, whole-body CT (WBCT) is both safe and clinically justified, even in the management of hemodynamically unstable patients [47].

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## 9. Use of Point-of-Care Ultrasonography (POCUS)

We advise the use of point-of-care ultrasonography (POCUS), including eFAST, in patients with thoracoabdominal injuries IF FEASIBLE

**Strength of recommendation:** Conditional

**Level of evidence:** Low

**Rationale:**

## The Role of Point-of-Care Ultrasound (POCUS)

### Pre-hospital Ultrasound (PHUS)

The diagnostic accuracy of pre-hospital ultrasound (PHUS) is considered adequate for identifying pneumothorax, free intra-abdominal fluid, and hemoperitoneum. A systematic review involving 2,889 trauma patients demonstrated high sensitivity and specificity, with several studies noting that PHUS findings led to direct changes in clinical management [48].

While a more recent review of 3,317 patients confirmed the feasibility of PHUS and its impact on transport decisions, significant inconsistencies in protocols and outcome measures currently prevent a formal meta-analysis of its global efficacy [49].

### In-Hospital POCUS and the FAST Protocol

In the hospital setting, the **Focused Assessment with Sonography in Trauma (FAST)** remains a cornerstone of the primary ATLS survey for detecting hemorrhage in the plural, pericardial, and peritoneal cavities [50].

While FAST exhibits high specificity (0.96), its sensitivity is variable (0.74), often depending on the patient population and the anatomical region affected [50]. Notably, a negative FAST examination cannot definitively exclude internal injury and must be validated against a reference standard, such as CT, especially in symptomatic patients.

This limitation is particularly critical in hemodynamically unstable patients. An analysis of the **PROMTT trial** revealed that nearly 7% of hypotensive patients with a negative FAST still required a laparotomy within six hours of admission [51].

Consequently, in the presence of unexplained hypotension, significant intra-abdominal hemorrhage must be suspected regardless of ultrasound findings [51].

### Advanced Techniques and Regional Accuracy

POCUS appears to yield higher diagnostic sensitivity for thoracic and cardiac injuries compared to abdominal assessments [50, 52, 53].

To improve the utility of ultrasound in trauma, several specialized techniques have been proposed:

- **FAST-PLUS Protocol:** Incorporating a transverse scan of the pubic symphysis can identify unstable pelvic fractures with high correlation to CT findings [54].
  - **Patient Positioning:** Rolling a patient to the right lateral position during the exam may increase sensitivity by shifting fluid into more visible acoustic windows, potentially converting false-negative results into true positives [55].
-

## 10. Early Whole-Body CT (WBCT)

We suggest early imaging using contrast-enhanced whole-body CT (WBCT) for detection and identification of injury type and bleeding source after patient stabilization, if available.

**Strength of recommendation:** Conditional

**Level of evidence:** Moderate

**Rationale:**

### Efficacy of Whole-Body Computed Tomography (WBCT)

#### Diagnostic Accuracy and Clinical Utility

Observational and retrospective evidence consistently supports the use of **Whole-Body Computed Tomography (WBCT)** for its superior diagnostic accuracy, time-saving capabilities, and ability to localize hemorrhage sources rapidly [45, 56].

In multicenter studies, CT has demonstrated 100% sensitivity for identifying retroperitoneal hematomas and intra-abdominal injuries in patients presenting with the "seat belt sign" (abrasions or ecchymosis) [57, 58].

#### Evidence from the REACT-2 Trial

The **REACT-2 trial**, the only prospective randomized controlled trial (RCT) in this field, compared immediate WBCT to conventional selective CT. While the trial found no significant survival difference between the two groups for general polytrauma or traumatic brain injury (TBI) [59], a secondary analysis yielded critical insights for bleeding patients. For the subset of patients requiring emergency hemorrhage control, immediate WBCT was associated with an absolute risk reduction in mortality of 11.2% [60].

#### Time-Critical Outcomes

The implementation of WBCT significantly reduces the total time spent in the emergency department [61].

Furthermore, evidence suggests a direct correlation between the speed of imaging and survival; a median time of 19 minutes from hospital admission to CT has been significantly associated with a decrease in mortality caused by exsanguination [62].

#### Refined Clinical Criteria

Based on secondary data from the REACT-2 study, a set of 10 clinical criteria with high positive predictive value for severe injury has been developed to assist in identifying candidates for immediate WBCT [63].

However, practitioners should note that these criteria are derived from post hoc analyses and may not be universally applicable. A targeted diagnostic approach is often warranted, as

hemodynamic instability can occasionally impair the sensitivity of contrast-enhanced CT in detecting active extravasation [64].

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## 11. Repeated Haemoglobin/Haematocrit Monitoring

During resuscitation, we recommend repeating Hb and/or Hct measurements within 30 – 60 minutes, as initial normal values may mask early bleeding.

**Strength of recommendation:** Strong

**Level of evidence:** Moderate

**Rationale:**

### Haemoglobin and Haematocrit Monitoring

#### Limitations of Initial Measurements

In the acute phase of trauma, a single, baseline hemoglobin (Hb) measurement is often an unreliable indicator of the extent of blood loss. This diagnostic limitation stems from the physiological lag in fluid equilibration and the confounding effects of early crystalloid resuscitation, which may artificially dilute or temporarily mask the severity of the hemorrhage [66, 72].

Because initial Hb levels often remain within the normal range during the early stages of catastrophic bleeding, relying solely on admission values can lead to a dangerous underestimation of injury severity [73, 74].

#### Serial Monitoring and Emerging Technologies

Current evidence emphasizes the necessity of **serial Hb or hematocrit (Hct) measurements** to accurately track the progression of bleeding and the patient's response to resuscitation [67–69].

Clinical guidelines suggest repeating these tests every 30 to 60 minutes during the initial assessment phase, as significant downward trends in Hct even during active fluid administration are highly predictive of ongoing hemorrhage [70, 71].

Furthermore, recent advancements in **non-invasive Hb monitoring** have demonstrated high precision and close correlation with traditional laboratory-based results, offering a potential tool for continuous, real-time assessment in trauma settings [65].

#### Predictive Value in Trauma

Longitudinal changes in Hb and Hct levels are essential for identifying patients who require blood transfusions or urgent surgical intervention [68, 69]. These markers, when combined with other laboratory indicators such as base excess and fibrinogen levels, assist in forming a comprehensive picture of the patient's coagulation status and overall injury severity [72, 73].

Ultimately, the "stop the bleed" priority is best supported by frequent reassessment rather than a single static measurement [74].

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## 12. Lactate and Base Deficit Monitoring

We recommend measurement of blood lactate as a sensitive test to estimate and monitor the extent of bleeding and tissue hypoperfusion; In the absence of lactate measurements, base deficit may represent a suitable alternative. if available.

**Strength of recommendation:** Conditional

**Level of evidence:** Moderate

**Rationale:**

### Lactate and Base Deficit as Diagnostic Tools

For the initial assessment of patients with traumatic hemorrhage, the measurement of serum lactate and base deficit is essential. These markers serve as highly sensitive indicators for estimating the severity of blood loss and monitoring the degree of tissue hypoperfusion [75, 76].

Unlike traditional vital signs, such as systolic blood pressure, which may remain compensated in the early stages of shock, lactate and base deficit provide an objective window into cellular dysfunction and the adequacy of oxygen delivery (DO<sub>2</sub>) [75, 76].

### Pathophysiological Rationale

The clinical utility of these markers is rooted in cellular metabolic shifts during hemorrhagic shock. When catastrophic bleeding reduces systemic oxygen delivery, tissues are forced to transition from aerobic to anaerobic metabolism to sustain energy production. This shift results in the accumulation of lactate, a metabolic byproduct that often signals critical hypoperfusion before the onset of overt clinical hypotension [76].

### Lactate Clearance and Resuscitation Endpoints

In the context of trauma resuscitation, the primary objective is to reverse tissue debt and restore metabolic homeostasis. Consequently, "lactate clearance" the observed reduction of lactate levels over time—is considered a superior prognostic indicator and a more definitive endpoint for resuscitation than the mere normalization of arterial blood pressure [77].

### Base Deficit and Metabolic Acidosis

Base deficit, derived from arterial blood gas (ABG) analysis, quantifies the concentration of base required to restore the blood to a physiological pH. It is a direct reflection of metabolic acidosis in trauma patients [78, 79].

As lactate a strong acid accumulates, it releases hydrogen ions (H<sup>+</sup>) into circulation. These ions are neutralized by the body's bicarbonate (HCO<sub>3</sub><sup>-</sup>) buffering system; the subsequent

consumption of bicarbonate stores results in an increasingly negative base deficit, signaling worsening physiological status [80].

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### 13. Monitoring of Haemostasis

We recommend the early and repeated monitoring of haemostasis, using a traditional laboratory determination such international normalised ratio (INR), and platelet count.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

#### Conventional Coagulation Testing (CCT)

##### Prognostic Value and Mortality Correlation

Conventional coagulation tests (CCTs) including International Normalized Ratio (INR), Prothrombin Time (PT), activated Partial Thromboplastin Time (aPTT), platelet count, and fibrinogen concentration remain foundational in the early detection of trauma-induced coagulopathy. Because coagulopathy is a primary driver of mortality in trauma victims, the widespread availability and diagnostic reach of CCTs are critical [81].

Research indicates that even in patients with moderate injuries, abnormal CCT results upon admission are strongly associated with increased mortality [81].

Recent evidence suggests that CCTs may offer superior predictive power for mortality compared to viscoelastic hemostatic assays (VHAs), such as Rotational Thromboelastometry (ROTEM) or Thromboelastography (TEG). Specifically, a 2025 prospective study demonstrated that prolonged INR and clotting times are more reliable prognostic indicators for survival than VHA parameters alone [82].

##### Integration into Massive Transfusion Protocols (MTP)

CCTs are essential components of massive transfusion protocols, particularly in resource-constrained environments where advanced assays may not be available. While VHAs like ROTEM may exhibit higher sensitivity in diagnosing the specific nuances of trauma-induced coagulopathy (TIC), the clinical relevance of CCTs remains undisputed; patients presenting with abnormal CCT values experience significantly higher mortality rates [83].

Consequently, these tests remain a primary guide for the targeted administration of blood products during acute resuscitation [82, 83].

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### 14. Restricted Volume Replacement and Blood Pressure Targets

We recommend the use of a restricted volume replacement strategy in the absence of clinical evidence of brain injury with a target systolic blood pressure of 80–90 mmHg (mean arterial pressure 50–60 mmHg) in the initial phase following trauma, until major bleeding has been stopped.

**Strength of recommendation:** Strong

**Level of evidence:** Moderate

**Rationale:**

## Permissive Hypotension in Haemorrhagic Shock

### Rationale and Mechanism

Permissive hypotension is a resuscitation strategy utilized in trauma patients with active bleeding, characterized by maintaining systolic blood pressure at sub-normal levels until definitive surgical or radiological hemorrhage control is secured. This is achieved through restricted volume replacement. The physiological objective of this approach is to prevent the "popping of the clot" the disruption of nascent hemostatic plugs which is a common complication of aggressive fluid resuscitation and high-pressure flow [84].

### Clinical Evidence and the "Lethal Triad"

Conventional resuscitation models that prioritize the rapid restoration of normotension are frequently associated with the development of dilutional coagulopathy, hypothermia, and metabolic acidosis. These three conditions comprise the "lethal triad," which significantly drives mortality in severely injured patients [85].

Clinical evidence, most notably the landmark trial by Bickell et al., has demonstrated a distinct survival advantage in patients with penetrating truncal trauma when fluid resuscitation is limited or delayed until the point of surgical intervention [86].

### Contraindications and Implementation

Although permissive hypotension is a cornerstone of contemporary trauma management, its application requires careful clinical judgment. This strategy is generally contraindicated in patients with concomitant traumatic brain injury (TBI), where maintaining cerebral perfusion pressure is paramount, and in scenarios involving prolonged transport times where the risk of protracted tissue ischemia may outweigh the benefits of restricted filling [84, 85].

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## 15- In patients with severe TBI (GCS ≤ 8)

We recommend maintaining mean arterial pressure ≥ 80 mmHg.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

## Restrictive Fluid Resuscitation and Permissive Hypotension

### Clinical Evidence and Mortality Benefits

The contemporary management of trauma-induced hypotension has shifted from aggressive fluid administration toward restrictive volume replacement and permissive hypotension. This paradigm was largely established by a seminal randomized controlled trial (RCT) in the 1990s, which demonstrated improved survival in patients with penetrating injuries [86].

Recent meta-analyses of RCTs have since confirmed that in trauma patients without traumatic brain injury (TBI), restrictive fluid strategies significantly decrease mortality compared to traditional high-volume resuscitation [87, 88].

These findings are further corroborated by several meta-analyses of retrospective and mixed-methodology studies, which consistently show superior outcomes when normotension is not the immediate target [89–92].

### Complications of Aggressive Resuscitation

Retrospective data indicate that aggressive resuscitation—often initiated in the pre-hospital setting—is associated with a higher incidence of adverse outcomes. These include increased mortality, a greater necessity for damage control laparotomy, and the development of the "lethal triad" (coagulopathy, acidosis, and hypothermia). Furthermore, aggressive fluid protocols are linked to higher rates of multi-organ failure, nosocomial infections, increased transfusion requirements, and prolonged intensive care and hospital stays [93–95].

Recent evidence suggests these risks extend to pediatric populations, where higher initial crystalloid volumes are also associated with increased mortality [96].

### Contraindications and Clinical Precautions

Despite its benefits, permissive hypotension is strictly contraindicated in patients with TBI or spinal cord injuries. In these cases, maintaining adequate mean arterial pressure is vital to ensure cerebral and spinal cord perfusion and oxygenation. The optimal balance between fluid administration and vasopressor use in these scenarios remains a subject of ongoing research, making rapid hemorrhage control the highest priority [97]. Additionally, this strategy should be applied with caution in elderly patients and those with a history of chronic arterial hypertension, as they may have a higher baseline requirement for organ perfusion.

## Summary and Future Directions

Current literature supports a damage control resuscitation strategy that targets a reduced systolic blood pressure of **80–90 mmHg** in the absence of CNS injury. However, the existing evidence base contains limitations, including small sample sizes in RCTs and potential selection bias in retrospective cohorts. While the shift toward restrictive volume replacement is clinically justified by the available data, further confirmation through adequately powered, high-quality prospective RCTs is necessary to refine these protocols.

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### 16. Use of Noradrenaline When Restricted Volume Replacement Fails

We recommend the administration of **noradrenaline** to maintain target arterial blood pressure, if a restricted volume replacement strategy does not achieve the target blood pressure.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

## Role of Vasopressors and Inotropes in Haemorrhagic Shock

### Noradrenaline and Early Resuscitation

The use of noradrenaline and other vasopressors during the acute phase of trauma remains controversial. Several retrospective analyses and systematic reviews have associated vasopressor use with increased mortality or a lack of clinical benefit [98–102, 104].

One study noted that mortality was not independently linked to vasopressors unless epinephrine was administered [103]. However, these findings are often limited by significant selection bias, as patients receiving vasopressors are typically more critically ill than those who are not [104].

Current evidence supports a strategy of **restricted volume replacement and permissive hypotension** (targeting a systolic blood pressure of 80–90 mmHg) without vasopressors in the initial stages of resuscitation. There is a theoretical concern that early vasopressor use may worsen organ ischemia by inducing excessive vasoconstriction. However, if these conservative measures fail and life-threatening hypotension persists (SBP < 80 mmHg), the transient use of noradrenaline is recommended to sustain tissue perfusion and prevent cardiovascular collapse.

### Arginine Vasopressin (AVP)

Haemorrhagic shock involves a biphasic physiological response: an initial sympathoexcitatory phase followed by a sympathoinhibitory, vasodilatory phase that can severely reduce vascular tone [105]. Based on the hypothesis that profound shock leads to a deficiency in endogenous arginine vasopressin, clinical trials have investigated its supplementation.

A well-designed randomized controlled trial (RCT) involving 100 patients demonstrated that low-dose arginine vasopressin (4 IU bolus followed by 0.04 IU/min) significantly reduced the

requirement for blood product transfusions [106]. These results align with earlier data showing that adding vasopressin to resuscitation fluids decreases the total volume of fluid required over five days without increasing adverse events or 30-day mortality [107]. While promising, further high-powered research is necessary to confirm the impact of AVP on long-term morbidity and mortality.

## Managing Cardiac Dysfunction

Cardiac dysfunction in trauma patients may result from myocardial contusion, pericardial effusion, or secondary to increased intracranial pressure from brain injury. In these instances, inotropic agents such as **dobutamine or epinephrine** are indicated. In the absence of advanced hemodynamic monitoring, cardiac dysfunction should be suspected if a patient remains hypotensive despite adequate fluid expansion and noradrenaline administration.

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### 17. Choice of Crystalloid Solutions

We recommend that fluid therapy using a 0.9% sodium chloride and/or ringer lactate or balanced crystalloid solution be initiated in the hypotensive bleeding trauma patient.

**Strength of recommendation:** Strong

**Level of evidence:** Moderate

**Rationale:**

## Crystalloid Selection and Fluid Volume

### Balanced Solutions vs. Normal Saline

While the use of crystalloids is fundamental to a restrictive fluid strategy in trauma, the optimal type of solution remains a subject of active debate. Historically, **0.9% sodium chloride (Normal Saline)** was the standard; however, its use is increasingly scrutinized due to the risk of inducing hyperchloremic acidosis and acute kidney injury (AKI), both of which may negatively impact survival [108].

In contrast, **balanced electrolyte solutions** (such as Ringer's Lactate or Plasma-Lyte) feature chloride concentrations closer to physiological levels. A large-scale RCT involving 15,802 patients suggested that balanced solutions reduce a composite outcome of death, new renal-replacement therapy, and persistent renal dysfunction [109].

However, subsequent high-quality evidence including the **BaSICS trial** and recent meta-analyses found no significant differences in 30-day mortality or hospital length of stay when comparing balanced solutions to saline in broader critically ill populations [110–112].

## Clinical Recommendations

Despite the lack of a definitive survival benefit in all trials, current trauma guidelines favor **balanced electrolyte solutions** for initial management. If 0.9% sodium chloride is utilized, it

should be restricted to a maximum volume of **1.0–1.5 L**. Saline is specifically contraindicated in patients with severe metabolic acidosis, particularly when hyperchloremia is present.

## Role of Colloids and Coagulation

The preference for crystalloids as the primary resuscitation fluid is also driven by the known inhibitory effects of synthetic colloids (such as hydroxyethyl starch and gelatin) on platelet function and the coagulation cascade.

Research indicates that while fibrinogen concentrates can partially mitigate this dilutional and functional coagulopathy, the effect depends heavily on the type and concentration of the colloid used [113, 114]. Therefore, colloid infusions should be reserved as a secondary option for cases of excessive hemorrhage where crystalloids and vasopressors are insufficient to maintain essential tissue perfusion.

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### 18. Avoidance of Hypotonic Solutions in TBI

We recommend that hypotonic solutions be avoided during resuscitation of patients with haemorrhagic shock in addition to Traumatic brain injury.

**Strength of recommendation:** Strong

**Level of evidence:** Moderate

**Rationale:**

## Fluid Management in Traumatic Brain Injury (TBI)

In patients suffering from Traumatic Brain Injury, the selection of resuscitation fluids is restricted by the need to maintain cerebral osmotic pressure. **Hypotonic solutions**, including Ringer's lactate and hypotonic albumin, should be strictly avoided. The administration of these fluids can lower serum osmolality, potentially driving a fluid shift into damaged cerebral tissues and exacerbating life-threatening cerebral edema [115].

This clinical caution is supported by secondary analysis from the **PROMMTT study**, which evaluated the impact of pre-hospital fluid choice. The data revealed that the use of Ringer's lactate was associated with a higher adjusted mortality rate in the TBI population when compared to the use of isotonic normal saline [115].

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### 19. Restriction of Colloid Use

We advise that the use of colloids to be restricted due to the adverse effects on haemostasis.

**Strength of recommendation:** Conditional

**Level of evidence:** Low

**Rationale:**

## Adverse Effects of Colloids on Haemostasis

### Mechanisms of Coagulopathy

The clinical rationale for restricting the use of synthetic colloids, particularly **Hydroxyethyl Starches (HES)** and **Dextrans**, is primarily based on their deleterious impact on the coagulation system [116].

These agents impair hemostasis through a dual mechanism:

1. **Dilutional Coagulopathy:** Like all large-volume intravenous fluids, they reduce the systemic concentration of platelets and essential clotting factors.
2. **Specific Anticoagulant Effects:** Colloids exert direct biochemical interference with the coagulation cascade, distinct from simple dilution [117–119].

### Direct Haemostatic Interference

Colloid molecules directly compromise the integrity of the blood clot in several ways:

- **Platelet Dysfunction:** They interfere with both platelet adhesion and aggregation, reducing the effectiveness of the initial platelet plug.
- **Factor Inhibition:** They decrease the activity of critical coagulation components, specifically **Factor VIII** and **Factor XIII** [120].
- **Fibrin Stability:** Colloids compromise the polymerization and cross-linking of fibrin, resulting in a fragile, unstable clot that is highly susceptible to premature lysis.

This impairment of the coagulation system is **dose-dependent**, meaning the risk of exacerbated hemorrhage increases significantly as larger volumes of synthetic colloids are administered [120, 121].

While albumin-induced coagulopathy is documented, it is generally considered less severe and more readily reversible with fibrinogen concentrates than the coagulopathy induced by synthetic alternatives [121].

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## 20. Target Haemoglobin After Bleeding Control

We recommend a target haemoglobin of 7–9 g/dL after controlling the source of bleeding.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

# Post-Operative Haemoglobin Targets and Transfusion Strategy

## The Restrictive Transfusion Model

Once definitive hemorrhage control is achieved, a restrictive red blood cell (RBC) transfusion strategy is recommended, targeting a hemoglobin (Hb) concentration of **7–9 g/dL**. This threshold is supported by high-quality evidence indicating that a restrictive approach is non-inferior to more liberal strategies regarding patient morbidity and mortality [122].

The landmark **TRICC trial** established the safety of this lower threshold for the majority of critically ill and stable patients [122].

Adopting a restrictive range is clinically advantageous as it mitigates the risks of transfusion-related complications, such as:

- **Transfusion-Associated Circulatory Overload (TACO)**
- Nosocomial infections
- Immunomodulation and suppression [123]

By maintaining this target, clinicians utilize the body's physiological compensatory mechanisms to ensure tissue oxygenation while avoiding the adverse effects of excessive blood product administration [123, 124].

## Clinical Exceptions

While the **7–9 g/dL** target is the standard for most patients, specific populations require individualized management. Patients with acute ischemic conditions, most notably **Acute Coronary Syndrome (ACS)** or **Traumatic Brain Injury (TBI)** may necessitate a more liberal transfusion threshold to optimize cerebral and myocardial oxygen delivery and prevent secondary injury [124].

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## 21. Prevention and Management of Hypothermia

We recommend early application of measures such covering the patient and warm fluids to reduce heat loss and warm the hypothermic patient to achieve and maintain normothermia.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

## Hypothermia in Trauma Management

### Impact on Mortality and Coagulopathy

Hypothermia is a critical independent predictor of poor outcomes in trauma, consistently correlating with increased mortality rates and a higher demand for blood products [125, 126].

A core body temperature falling below 35 °C often triggers a cascade of metabolic acidosis, hypotension, and impaired hemostasis, serving as a primary driver of trauma-induced coagulopathy [127].

The prognostic implications of heat loss are severe; logistic regression analyses indicate that once core temperatures drop below 34 °C, the probability of mortality exceeds 80%. This elevated risk persists regardless of the patient's injury severity score (ISS), degree of shock, or the volume of transfusions received [128].

## Hypothermia in Traumatic Brain Injury (TBI)

In the context of severe TBI, temperature regulation is particularly vital. Both spontaneous hypothermia upon hospital admission and therapeutically induced hypothermia have been significantly linked to increased mortality rates, suggesting that maintaining normothermia is essential for neurological preservation and survival in these patients [129, 130].

## Prevention and Rewarming Strategies

Aggressive measures to maintain normothermia should begin in the prehospital phase and continue through definitive care.

Primary strategies include:

- **Passive Warming:** Removal of wet clothing and insulation to prevent ongoing heat loss.
- **Active Warming:** Increasing the ambient temperature of the resuscitation room and utilizing forced-air warming blankets.
- **Internal Warming:** Infusion of intravenous fluids warmed to 39–40 °C and, in extreme or refractory cases, the use of extracorporeal rewarming [131].

Furthermore, the use of specialized hypothermia management kits—originally developed for military tactical combat casualty care—is increasingly recommended for civilian use. These compact kits provide sustained dry heat for up to 10 hours and represent a practical, cost-effective adjunct for preventing the lethal progression of trauma-associated cooling [131].

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## 22. Damage Control Surgery

We suggest damage control surgery in the severely injured patient if the definitive surgery to control the source of bleeding is complicated and time-consuming (>90 minutes) in the presence of severe persistent coagulopathy, severe acidosis with base deficit >15 mmol/L or lactate >5 mmol/L, hypothermia <34°C, or signs of ongoing bleeding despite the initial attempts of bleeding control with systolic BP persistently <90 mmHg.

**Strength of recommendation:** Conditional

**Level of evidence:** Low

**Rationale:**

## Damage Control Surgery (DCS)

### Definition and Historical Context

In the management of severe hemorrhagic shock, the delay of definitive hemorrhage control significantly increases morbidity and mortality. To address the needs of exsanguinating patients, **Damage Control Surgery (DCS)** was formalized by Rotondo et al. in 1993. Originally defined for abdominal trauma, the approach prioritizes the initial control of active bleeding and contamination, followed by intraperitoneal packing and rapid temporary closure [132, 133].

This strategy intentionally shifts the focus from definitive anatomical repair to the abbreviation of the initial operation. This allows for a period of intensive resuscitation in the ICU, where the patient's hemodynamic profile, temperature, and coagulation status can be stabilized prior to returning to the operating room for final management [133].

### Benefits and Clinical Risks

The primary advantage of DCS is the stabilization of the "lethal triad," providing clinicians with the necessary time to reverse physiological insults before complex reconstructive surgery is attempted [134].

However, DCS carries a high risk of post-operative complications, including:

- Surgical site infections and sepsis.
- Incisional hernias and wound dehiscence.
- Abdominal compartment syndrome.
- The inherent physiological burden of multiple subsequent surgical procedures [134].

### Reducing the Need for Damage Control

While DCS remains a life-saving intervention, recent shifts in **Damage Control Resuscitation (DCR)** including the early correction of coagulopathy, rapid hemorrhage control, and the avoidance of excessive crystalloid administration have been shown to improve physiological stability earlier in the treatment timeline. These adjunctive strategies may potentially reduce the necessity for full damage control procedures in a subset of severely injured patients [135].

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### 23. Pelvic Binder Use

We recommend the adjunct use of a pelvic binder or pelvic sheet to limit life threatening bleeding in the presence of a suspected pelvic fracture.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

## Emergency Pelvic Stabilization

### Role of External Stabilization

For patients presenting with unstable pelvic ring fractures, emergency external stabilization is a critical component of initial hemorrhage control. These techniques are widely utilized because they reduce pelvic volume and provide mechanical stability, which facilitates the tamponade of venous bleeding and protects nascent clots from disruption [136].

### Clinical Application and DCO Principles

The use of non-invasive pelvic binders has become a standard of care in the pre-hospital and early clinical phases of resuscitation. However, the decision to apply such a device must be tailored to the patient's specific injury morphology. In alignment with the principles of **Damage Control Orthopaedics (DCO)**, the primary objective is to prioritize rapid physiological stabilization and hemorrhage control over definitive anatomical fixation [137–139].

Data from major registries indicate that while binders are highly effective for "open-book" (anteroposterior compression) patterns, their appropriateness depends on a careful assessment of the fracture pattern to ensure that the compression does not exacerbate certain types of lateral compression injuries [137].

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## 24. Topical Haemostatic Agents

We consider the use of topical haemostatic agents with packing for venous or moderate arterial bleeding associated with parenchymal injuries.

**Strength of recommendation:** Conditional

**Level of evidence:** Moderate

**Rationale:**

## Local Haemostatic Agents

### Role as Surgical Adjuncts

A diverse array of local hemostatic agents is currently available to supplement traditional surgical methods, such as suturing or cauterization. These topical adjuncts are particularly advantageous in scenarios where anatomical access is restricted or when dealing with diffuse, non-compressible bleeding from parenchymal organs, bone, or vascular anastomoses [140, 142].

### Clinical Evidence and Survival

The efficacy of these agents is well-documented in high-acuity settings. A retrospective review of the UK Joint Trauma Registry demonstrated that the early application of hemostatic dressings in severely injured military casualties was significantly associated with increased survival rates [140].

Similarly, in the prehospital setting, a systematic review corroborated the value of these dressings in managing catastrophic external hemorrhage before definitive surgical intervention could be reached [148].

## Specialized Applications

Extensive clinical experience in humans has validated the use of various formulations across multiple surgical disciplines:

- **Gelatine-Thrombin Matrices:** Highly effective in vascular, renal, and spinal surgeries for managing active oozing [141, 145, 146].
  - **Fibrin Sealants:** Proven to improve haemostasis in peripheral vascular procedures [142].
  - **Oxidized Cellulose and Collagen-Based Composites:** Utilized effectively in thoracic surgery and for controlling bone-surface bleeding at donor sites [143, 144, 147].
  - **Intra-abdominal Packing:** The combination of traditional laparotomy pads with haemostatic gauze (e.g., QuikClot) during damage control laparotomy has been analysed for safety and efficacy in stabilizing patients with profound intra-abdominal haemorrhage [149].
- 

## 25. Tranexamic Acid (TXA)

We recommend TXA administration in trauma patients who are bleeding or at risk of significant bleeding, as soon as possible and within 3 hours of injury at a loading dose of 1 g IV over 10 min, followed by 1 g IV infusion over 8 hours.

**Strength of recommendation:** Strong

**Level of evidence:** High

**Rationale:**

### Tranexamic Acid (TXA) in Trauma Resuscitation

#### Clinical Efficacy and Mortality Benefit

Tranexamic acid (TXA) has established itself as a cornerstone in the management of trauma patients at risk of significant hemorrhage. Large-scale clinical trials have demonstrated that its administration can reduce overall mortality by 1.5% and, more significantly, decrease deaths specifically attributed to bleeding by approximately one-third [150, 151]. Its mechanism as an antifibrinolytic helps stabilize formed clots, preventing their premature breakdown during the hyperfibrinolytic state often seen in trauma-induced coagulopathy.

#### Pre-hospital Administration and Dosing Strategies

The transition of TXA administration to the pre-hospital setting has been a major focus of recent research. In a randomized controlled trial of 927 trauma patients, a 1 g pre-hospital dose of TXA administered within two hours of injury resulted in a 30-day mortality rate of 8.1%, compared to 9.9% in the placebo group [155].

The impact of subsequent in-hospital dosing appears to follow a dose-response relationship. Data indicates that following a pre-hospital dose, 30-day mortality rates were lowest (7.3%) in patients who received a follow-up 1 g bolus plus a 1 g infusion, compared to those receiving an infusion only (7.8%) or no additional in-hospital TXA (9.3%) [155].

## The "Golden Hour" and Patient Selection

The survival benefit of TXA is highly time dependent. Secondary analysis confirms that patients treated within one hour of injury particularly those with a shock index < 0.9 experienced a 65% lower likelihood of 30-day mortality [155].

Furthermore, early administration is associated with a lower incidence of multiorgan failure and reduced 24-hour transfusion requirements. Conversely, delayed treatment (> 3 hours from injury) has been shown in related literature to potentially increase the risk of death, reinforcing the necessity of early intervention [150, 155].

Recent applications have also expanded into Traumatic Brain Injury (TBI), where TXA has been shown to reduce the progression of intracranial hemorrhagic masses and improve survival in cases of mild-to-moderate TBI, provided it is administered promptly [151–154].

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## 26. Balanced Blood Product Transfusion

We recommend transfusion of pRBCs: FFP: Platelets in ratio following the massive transfusion protocols, In the initial management of patients with suspected massive haemorrhage.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

### Initial Transfusion Strategies: Fixed-Ratio Protocols

#### Empirical Ratio-Driven Resuscitation

During the critical interval between hospital arrival and the availability of laboratory coagulation results, many trauma centers employ an empirical, ratio-driven transfusion strategy. This approach involves the administration of Fresh Frozen Plasma (FFP), platelets, and packed Red Blood Cells (pRBCs) in fixed ratios to pre-emptively manage trauma-induced coagulopathy. While the precise benefit of fixed ratios remains a subject of debate, this strategy aims to mimic the composition of whole blood and prevent the dilution of clotting factors [157].

#### The PROPPR Trial and Haemostatic Outcomes

The definitive evidence for ratio-driven resuscitation comes from the **PROPPR trial**, which randomized 680 severely injured patients to receive blood products in either a **1:1:1** ratio (where platelets are included in the first transfusion pack) or a **1:1:2** ratio (where platelets are delayed until the second pack) [156].

The study found that while overall 24-hour and 30-day mortality rates were comparable between the two groups.

The **1:1:1 ratio** offered significant physiological advantages:

- **Improved Haemostasis:** Patients in the 1:1:1 group achieved formal haemostasis significantly faster than those in the 1:1:2 group.
- **Reduced Exsanguination:** There was a notable reduction in deaths specifically attributed to early exsanguination in the 1:1:1 cohort [156].

Consequently, fixed-ratio protocols, particularly the 1:1:1 approach are widely integrated into Massive Transfusion Protocols (MTPs) to stabilize patients during the hyperacute phase of bleeding until goal-directed therapy can be initiated [157].

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## 27. Calcium Monitoring and Supplementation

We recommend that ionised calcium levels be monitored and maintained within the normal range following major trauma and especially during massive transfusion. We recommend the administration of calcium to correct hypocalcaemia.

**Strength of recommendation:** Strong

**Level of evidence:** Low

**Rationale:**

### Calcium Homeostasis in Major Haemorrhage

In the management of patients with major trauma, maintaining normocalcaemia is a critical yet often overlooked component of resuscitation. It is strongly advised to perform frequent monitoring of **ionized calcium levels**, particularly during the activation of massive transfusion protocols.

#### Impact of Transfusion on Calcium Levels

The primary driver of hypocalcemia during resuscitation is the administration of large volumes of blood products. These products contain **citrate**, an anticoagulant that binds to free ionized calcium, rapidly lowering its systemic concentration. Since ionized calcium is a vital cofactor (Factor IV) in the coagulation cascade essential for the conversion of prothrombin to thrombin and the stabilization of fibrin low levels can severely exacerbate trauma-induced coagulopathy [158].

#### Clinical Intervention

Clinicians should maintain ionized calcium within normal physiological limits to support both hemostasis and myocardial contractility. Calcium supplementation (typically via calcium chloride or calcium gluconate) must be administered promptly whenever hypocalcemia is identified or empirically during rapid transfusion to prevent the "citrate toxicity" effect [158].

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## 28. Reversal of Vitamin K Antagonists (VKA)

We recommend the emergency reversal of vitamin K-dependent oral anticoagulants in the bleeding trauma patient with the early use of 5–10 mg intravenous phytomenadione (vitamin K1) in addition to FFP".

**Strength of recommendation:** Strong

**Level of evidence:** High

**Rationale:**

### Reversal of Vitamin K Antagonist (VKA) Therapy

#### Multi-Modal Reversal Strategy

In trauma patients presenting significant hemorrhage while on Vitamin K Antagonist (VKA) therapy (e.g., Warfarin), emergency reversal of anticoagulation is a critical priority. Current guidelines recommend a dual-action approach: the immediate administration of **four-factor Prothrombin Complex Concentrate (PCC)** supplemented with **5–10 mg of intravenous phytomenadione (Vitamin K1)** [159, 160].

#### Physiological Rationale

The necessity for this combined therapy is rooted in the distinct pharmacokinetics of the reversal agents:

- **Intravenous Vitamin K:** Provides the essential substrate for the hepatic synthesis of functional Factors II, VII, IX, and X. While vital for sustained hemostasis, the onset of action is delayed, typically requiring 6 to 12 hours for the liver to produce sufficient new clotting factors [161].
- **Prothrombin Complex Concentrate (PCC):** Offers a concentrated source of the Vitamin K-dependent factors, bypassing the need for hepatic synthesis and providing immediate correction of the International Normalized Ratio (INR).

#### PCC vs. Fresh Frozen Plasma (FFP)

Historically, Fresh Frozen Plasma (FFP) was utilized for VKA reversal; however, its use in trauma is increasingly restricted by volume limitations. Achieving effective reversal with FFP often necessitates dosages of **15–30 mL/kg**, which equates to 1 to 2 liters of fluid for an average adult. This high-volume requirement carries significant risks, including **Transfusion-Associated Circulatory Overload (TACO)** and acute cardiac strain [161].

Furthermore, high-quality randomized evidence, such as the **INCH trial**, has demonstrated that PCC is superior to FFP in achieving rapid normalization of the INR and limiting the expansion of life-threatening bleeding, particularly in cases of intracranial hemorrhage [161].

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### Research Needs:

- The study of coagulation parameters in polytrauma patients and their effects on outcome.
- Resuscitation of polytrauma patients: the management of massive extremity bleeding.
- Traumatic coagulopathy and massive transfusion: improving outcomes.

### Monitoring and Evaluating the Impact of the Guideline

- Hb and/or Hct measurements.
- International Normalized Ratio (INR)
- Platelet Count.
- Whole-Body CT (WBCT)
- Lactate and Base Deficit Monitoring
- Point-of-Care Ultrasonography (POCUS)

### Update of the Guideline:

This guideline will be updated whenever there is new evidence

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