

FIRST EDITION | OCTOBER 2026

Philosophy of Major Trauma

Clinical judgement from resuscitation
to rehabilitation

Mr Peyman Bakhshayesh

MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

Clinical Lead for General Trauma
Leeds Teaching Hospitals NHS Trust

Honorary Clinical Senior Lecturer, University of Leeds

About this edition

Philosophy of Major Trauma

Mr Peyman Bakhshayesh, MD, PhD, MBA

First edition, 13 October 2026

This book follows major trauma care from the first assessment to reconstruction, rehabilitation and return to everyday life. It is written for clinicians and trainees who need to connect anatomical injury with physiology, team decisions and the patient's future function.

The central proposition is that treatment must match the person's changing condition. Immediate threats require decisive action. Definitive reconstruction requires sufficient physiological capacity, and successful survival creates a continuing responsibility for recovery.

Reading the book

The introduction establishes the philosophy. Ten numbered chapters cover early care, regional injury and functional return. Reference numbering restarts within each chapter. The contents and PDF bookmarks link to chapter openings; source links are retained with the references.

Clinical scope

The principal focus is adult major trauma. Children, pregnancy and other specialist populations require adapted pathways. This educational text supports clinical judgement and does not replace current trauma-network protocols, specialist training or individual assessment. Guideline dates and limits of evidence are stated where relevant.

Editorial record

The author's supplied chapters, tables and illustrations have been brought into a single edition with continuous pagination. Spine is Chapter 6 and plexus injury is Chapter 7. The extremity chapter was completed from the available author dictation and cited guidance. Author information was checked against the professional homepage; the author's Drive literature collection informed the reading.

Copyright © 2026 Mr Peyman Bakhshayesh. Author-published. Institutional affiliations identify the author's roles and do not imply institutional endorsement. No patient photographs have been added. Anatomical illustrations are educational schematics.

Contents

Introduction	Introduction to Major Trauma Care	5
Chapter 1	Early Care in Major Trauma	15
Chapter 2	Head and Neck Injuries	26
Chapter 3	Thoracic Injuries in Major Trauma	34
Chapter 4	Abdominal Trauma	45
Chapter 5	Pelvis	54
Chapter 6	Spine and Spinal Precautions	68
Chapter 7	Plexus Injuries	77
Chapter 8	Vascular Injuries in Major Trauma	88
Chapter 9	Extremity Injuries	96
Chapter 10	Rehabilitation and Functional Return	103

References are placed at the end of the introduction and each chapter. The four plexus and nerve diagrams appear in Chapter 7. Tables retain their chapter-local numbering.

Click a contents entry or use the PDF bookmarks to move through the book. Click the book title in the running header to return here.

The author and the purpose

**Mr Peyman Bakhshayesh**

MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

Clinical Lead for General Trauma
Leeds Teaching Hospitals NHS TrustHonorary Clinical Senior Lecturer
University of Leeds

Mr Bakhshayesh graduated from Shiraz Medical School and undertook orthopaedic training in Sweden, with further specialist training in Sweden, Germany and the United Kingdom. His work includes major trauma, pelvic and acetabular injury, complex limb reconstruction, and foot and ankle surgery.

His doctoral research at Karolinska Institutet examined clinical and radiological aspects of traumatic pelvic ring injuries. His clinical practice, research and teaching underpin the perspective of this book: examine the whole patient, explain the purpose of each intervention and preserve the possibility of meaningful recovery.

The chapters retain the author's first-person reflections alongside the clinical evidence. Analogies such as the Formula One team and the spine as a foundation are teaching devices; the clinical discussion sets out their anatomical and physiological limits.

Kanakaris and Giannoudis' discussion of regional trauma networks, consulted in the author's Drive collection, provides relevant background to the integration of acute care and rehabilitation. The book develops that concern through the practical decisions of the trauma team.

Selected background source

Kanakaris NK, Giannoudis PV. Trauma networks: present and future challenges. BMC Medicine. 2011;9:121. doi:10.1186/1741-7015-9-121

Professional biography and photograph: peymanorthopaedics.world/about/

Author websites: peymanorthopaedics.world and seculardemocraticiran.world

INTRODUCTION

Introduction to Major Trauma Care

Mr Peyman Bakhshayesh, MD, PhD, MBA
Consultant Major Trauma

Preface: A philosophy of coordinated care

Major trauma confronts us with several urgent problems at once. A patient may be bleeding, struggling to breathe, losing consciousness and sustaining further injury with every unnecessary movement. The first responsibility of the trauma team is to recognise what threatens life now, act on it, and preserve the possibility of recovery. This requires technical skill, but also a shared understanding of priorities.

My philosophy is that the care of a severely injured person must be organised around the patient's physiology. An operation can be technically successful yet poorly timed. A scan can be diagnostically valuable yet dangerous if it delays control of haemorrhage. A fracture can look dramatic while a less visible injury presents the greater immediate threat. Good trauma care therefore depends on knowing what to do, when to do it, and when to stop.

I regard early trauma surgery as a continuation of resuscitation. Its immediate purpose may be to arrest bleeding, control contamination and stabilise injured structures, creating the conditions in which the patient can tolerate later reconstruction. The aim is to restore enough physiological reserve for recovery to remain possible.

This opening chapter introduces that way of thinking. It moves from the organisation of trauma services to the first assessment, the choice between imaging and immediate intervention, the objectives of emergency surgery, and the repeated examinations that protect patients from missed injuries. The chapters that follow can then examine these decisions in greater depth.

The central question is always: what does this patient need now to survive, and what must we preserve for their recovery?

Scope: a clinical and philosophical introduction for healthcare professionals. It describes principles and decision-making; procedural detail belongs in supervised training and current local protocols.

A system built around the injured person

Centralisation, expertise and shared responsibility

Modern trauma care developed through contributions from several countries. Germany's organised trauma services, North American regional systems and subsequent developments elsewhere all helped establish the value of specialist centres linked to surrounding hospitals. This was an international evolution, rather than a single sequence in which one national model simply passed to the next. In the United States, the American College of Surgeons published hospital trauma standards in 1976. Germany's TraumaRegister DGU began in 1993; the 2006 White Book helped underpin TraumaNetzwerk DGU, established in 2008. [1,2]

For England, the important dates are April 2010 for the London system and April 2012 for the national rollout of regional major trauma networks. The frequently recalled year 2013 marks early national reporting of improved outcomes, rather than the original England-wide launch. The other UK nations developed their services on their own timelines. [3]

What the outcome evidence shows

A major American study reported adjusted in-hospital mortality of 7.6% in trauma centres compared with 9.5% in non-trauma centres, and one-year mortality of 10.4% compared with 13.8%. The latter corresponds to an approximately 25% relative reduction in the risk of death. [4]

In England, Moran and colleagues examined care between 2008 and 2017. Their main analysis included 110,863 patients at 35 consistently reporting hospitals and found a 19% increase in case-mix-adjusted odds of survival over the study period. This was associated with system reorganisation and improvements in care. It was not a 19-percentage-point increase in survival, nor proof that centralisation alone caused every improvement; unadjusted mortality did not change. [5]

These findings support an organised network. A major trauma centre brings together emergency medicine, anaesthesia, critical care, radiology, surgery, nursing, transfusion services and rehabilitation. Its effectiveness also depends on pre-hospital triage, capable trauma units, clear transfer arrangements and access to the appropriate specialist at the appropriate time.

Centralisation matters because it concentrates readiness as well as expertise. In my view, its deepest achievement is to make responsibility collective: the severely injured patient enters a prepared team whose members understand both their own task and the tasks that must happen around them.

The first minutes

The Formula One analogy and the primary survey

I often explain the first assessment through a Formula One analogy. When a car arrives in the pit lane, a prepared team works quickly, with defined roles and a common plan. In trauma, the same qualities of preparation and coordination are essential. The analogy is a memory aid: the person before us has a history, fears and a future that must remain central to our decisions.

ATLS provides a shared structure for immediate assessment and resuscitation. The familiar ABCDE sequence is now expressed as xABCDE in ATLS 11, drawing explicit attention to catastrophic external haemorrhage before progression through the primary survey. [6]

Step	Formula One memory aid	Clinical meaning
x	Stop a critical leak	Recognise and control catastrophic external bleeding immediately.
A	Air intake	Assess and secure the airway while protecting the cervical spine as indicated.
B	Air exchange	Assess ventilation and oxygenation; treat immediately life-threatening chest problems.
C	Oil and circulation	Assess perfusion, identify haemorrhage and restore effective circulation. Blood transports oxygen and supports clotting; it is more than a circulating fluid.
D	Electrical control	Assess consciousness, pupils and neurological function; consider brain or spinal injury and reversible causes of deterioration.
E	Inspect the whole vehicle	Expose sufficiently to identify injury, then protect warmth, dignity and the environment around the patient.

Assessment and treatment proceed together. Team members may perform several tasks simultaneously, while the leader maintains the order of priorities. Air entering the airway does not establish that the lungs are functioning adequately; a blood pressure reading does not establish that tissue perfusion is sufficient. The letters prompt questions that require clinical answers.

The primary survey begins on arrival and is repeated whenever the patient changes or after an intervention. It is not completed once and put aside. Each reassessment asks whether the last action worked and whether a new threat has appeared.

Imaging and the decision to intervene

The next destination follows the physiology

CT can rapidly define the distribution of injury and help the team plan treatment. In a patient who is responding to resuscitation, or whose haemodynamic status is normal, it may be the appropriate next step. Monitoring, resuscitation and suitably skilled accompaniment must continue throughout the transfer and scan. [7]

For a patient with uncontrolled haemorrhage and persistent haemodynamic instability despite resuscitation, diagnostic completeness cannot come before haemorrhage control. Imaging is limited to what is needed to direct immediate treatment. The destination may be an operating theatre, interventional radiology or a hybrid facility, according to the suspected source, the patient's condition and local capability. [7]

The expression "golden hour" captures the urgency of this work. I use it to encourage early decisive treatment, not as permission to wait or as a rigid biological deadline. Some threats must be treated within minutes. Others require a measured plan that avoids exposing an already exhausted patient to unnecessary operative stress.

CT findings must be integrated with examination and the patient's trajectory. An initial interpretation needs prompt communication, followed by review of the formal report and any subsequent amendments. A patient with ongoing abdominal concern may require continued observation, repeat assessment or further investigation despite an initially reassuring scan; bowel injury can be missed. [10]

Training for different stages of care

Programme	Principal contribution
ATLS Advanced Trauma Life Support	A common approach to early assessment, resuscitation and prioritisation. [6]
ASSET Advanced Surgical Skills for Exposure in Trauma	Cadaveric training in operative exposure, including access for vascular control. [8]
DSTC Definitive Surgical Trauma Care	Advanced surgical judgement and operative trauma care for surgeons managing complex injury. [9]

These programmes are complementary. DSTC is an educational programme; damage-control surgery is a treatment strategy. A surgeon needs the knowledge and technical preparation to intervene, supported by an anaesthetic, nursing and specialist team able to work towards the same immediate objective.

Surgery as resuscitation

Resuscitative, decontaminative and physiologically stabilising

I describe the first operation in a severely unstable patient through three connected purposes: resuscitation, decontamination and physiological stabilisation. This framing helps keep the operation proportionate to the patient's condition. It also makes the intended endpoint clear to everyone in theatre.

Control haemorrhage and protect threatened organs

Operative haemorrhage control is part of resuscitation. Appropriate proximal vascular control can be crucial, but the method depends on the source: pressure, packing, direct surgical control or endovascular treatment may have different roles. In a physiologically exhausted patient, an abbreviated operation can control immediate threats while postponing demanding reconstruction. [7,13]

Neurological deterioration requires urgent reassessment of oxygenation, perfusion and neurological findings, alongside early neurosurgical involvement. An expanding intracranial haematoma or other mass lesion may require evacuation or decompression; that decision depends on the lesion and clinical condition. Disability in the primary survey cannot be reduced to extradural bleeding alone. Selected patients with severe traumatic brain injury require intracranial pressure monitoring and specialist management. [12]

Other confined spaces also deserve attention. Orbital compartment syndrome threatens sight and may require emergency decompression by a competent clinician. A nasal septal haematoma requires urgent assessment and drainage when indicated. These are distinct injuries requiring appropriate expertise. [16,17]

Control contamination while preserving options

With bowel perforation, the immediate objective is to stop continuing contamination and address nonviable tissue. In damage-control surgery, injured bowel may be resected and the ends temporarily closed, leaving the bowel in discontinuity for planned reassessment. A stoma is an option, not an automatic requirement. Delayed anastomosis, diversion or further resection depends on physiology, bowel viability, contamination and the overall injury pattern. [10]

Skin is an important protective barrier, but closing a contaminated wound before adequate treatment can trap contamination. Open fractures need early antibiotics, formal wound excision and a coordinated plan for fixation and soft-tissue coverage. [11] Open joints similarly require urgent assessment and appropriate operative decontamination. Washing a wound alone is not equivalent to adequate debridement.

Stabilise without adding avoidable injury

Careful realignment and appropriate splintage or temporary external fixation can reduce pain, movement, further soft-tissue injury and bleeding. Neurovascular findings must be assessed and documented before and after intervention. The purpose is to protect both the patient and the limb until the safest definitive plan can be delivered. [11]

Restoring the patient's physiology

Look for a coherent response, not a single reassuring number

The surgeon and anaesthetist need a shared picture of the patient's physiological reserve. Has haemorrhage been controlled? Is oxygen delivery improving? Is resuscitation reversing shock? Can the patient tolerate further surgery? The answer develops over time and requires the team to connect bedside observations with laboratory trends.

The phrase "blood for blood" expresses my preference for recognising major haemorrhage as loss of oxygen-carrying capacity and haemostatic function, rather than treating it simply as a volume deficit. During major bleeding, red cells, plasma and platelets are delivered through the major haemorrhage protocol, with treatment refined by coagulation results and, where available, viscoelastic testing. Fibrinogen replacement, calcium, warming and timely tranexamic acid have roles according to the clinical situation and protocol. [13]

Serial blood gases help us follow lactate, pH and base deficit. Lactate trends can inform assessment of hypoperfusion and response to treatment, but require context. A normal pH can conceal a mixed acid-base disorder; an improving lactate does not by itself prove that haemorrhage has stopped or that major reconstruction is now safe. [13]

The bedside picture

I want to see the observations tell a consistent story: oxygenation and ventilation are adequate; circulation and peripheral perfusion are improving; urine output is appropriate to the clinical circumstances; temperature and coagulation are recovering; and the requirement for continuing support is understood. Urine output is valuable, but must be interpreted in the context of renal function, obstruction, medication and the time elapsed since resuscitation.

Central venous pressure can contribute contextual information when a central line is present, but a static CVP reading does not reliably establish fluid responsiveness. It should not be used alone to decide that resuscitation is complete or that further fluid is required. [14]

Inflammatory markers, including interleukin-6 and interferon-related pathways, are important research interests. For the practical decisions discussed here, however, I place the emphasis on repeated clinical assessment, blood-gas trends, haemostatic recovery and the observed response to treatment. No individual biomarker should replace that conversation between the teams.

Physiological stability is a judgement about the whole patient and the direction of change. It is not a certificate issued by a normal lactate.

The transition from temporary stabilisation to definitive reconstruction should therefore be deliberate. The team must agree what has improved, what remains vulnerable, and what additional physiological burden the proposed operation will impose.

Look again: the secondary and tertiary surveys

A normal scan is not the end of assessment

Once immediate threats have been addressed and resuscitation permits, the secondary survey adds a detailed history and systematic head-to-toe examination. It is more than another run through ABCDE, although the primary survey must be repeated whenever deterioration occurs. The secondary survey should begin when clinically appropriate; it does not wait until the following day. [6,15]

The tertiary survey provides a further deliberate search for missed or evolving injury, generally within 24 hours of admission. It brings together examination, imaging, investigation results and specialist plans. If sedation, intubation, pain or reduced consciousness limits the examination, those limitations are recorded and the assessment is repeated when the patient can participate. [15]

Examine what the scan may not show

An adult blunt-trauma whole-body CT commonly extends from the vertex to the mid-thigh. The phrase "whole body" can therefore mislead: it does not mean that every part of every limb has been adequately assessed. Hands, wrists, feet and other symptomatic areas may need separate examination and targeted imaging. Children require a selective imaging strategy rather than routine adult-style whole-body CT. [7]

The examination should be systematic and careful: inspect and gently palpate the scalp and face, assess the neck within appropriate spinal precautions, and reassess the chest, abdomen, pelvis, back and limbs. Where safe and appropriate, examine movement, sensation and perfusion. Forceful squeezing or unplanned movement of an injured region is not a substitute for a structured examination. [15]

In orthopaedic practice, the smaller injury can be overshadowed by the larger one. A wrist fracture may remain hidden behind the urgency of a pelvic injury; a painful foot may only become evident when mobilisation begins. The team must actively make room for these findings rather than assuming that a major scan has answered every question.

Record findings so they lead to action

Documentation should identify each known or suspected injury, the action required, the responsible team and any assessment still outstanding. The immediate purpose is patient safety and continuity of care. Accurate records also support rehabilitation planning, audit and legitimate medico-legal or insurance needs. These later uses do not replace the clinical duty to recognise and treat injury. [15]

After initial assessment, the patient may need theatre, interventional radiology, critical care, a major trauma or specialist ward, or transfer for a particular service. Discharge is appropriate only when assessment supports it and follow-up and safety-netting are arranged. The resuscitation room is an active treatment area within this pathway, not the final destination for ongoing care.

The responsibility that follows survival

The starting point for this book

The purpose of a trauma system extends beyond keeping a patient alive through the first operation. Survival opens the next set of responsibilities: relief of pain, recognition of every injury, preservation of function, rehabilitation and honest communication with the patient and family.

The Formula One comparison helps explain preparation and speed. The continuing care of a human being requires something further: patience with uncertainty, attention to the patient's own priorities, and the willingness to revise a plan when the clinical picture changes.

For me, the philosophy of major trauma care begins with four commitments: act promptly on immediate threats; make surgical ambition proportionate to physiology; look again for what may have been missed; and maintain responsibility across every handover. A team that follows these commitments can combine decisive action with thoughtful restraint.

This introduction establishes the framework for the chapters that follow. The patient's physiology determines the urgency, the team supplies the capability, and the prospect of meaningful recovery gives the work its direction.

About the author

Mr Peyman Bakhshayesh, MD, PhD, MBA, is a Consultant Trauma and Orthopaedic Surgeon working in major trauma at Leeds Teaching Hospitals NHS Trust and an Honorary Senior Lecturer at the University of Leeds. He graduated from Shiraz Medical School, completed orthopaedic training in Sweden, and undertook further specialist training in Sweden, Germany and the United Kingdom.

His clinical interests include complex fractures, pelvic and acetabular injuries, limb reconstruction, and foot and ankle surgery. His PhD at Karolinska Institutet examined clinical and radiological aspects of traumatic pelvic ring injuries. His teaching experience includes ATLS, DSTC, damage-control orthopaedics and ASSET. His work combines clinical practice, trauma research and education.

Author information: professional homepage and author-supplied Academic and Clinical CV, August 2026, available through Google Drive and consulted 13 October 2026.
Homepage: <https://peymanorthopaedics.world/about/>

References and web resources checked on that date.

References

Clinical sources and historical evidence

1. American College of Surgeons. Part 1: A Brief History of Trauma Systems.
[facs.org](https://www.facs.org) - open source
2. AUC - Akademie der Unfallchirurgie. 30 Jahre TraumaRegister DGU. 2023.
auc-online.de - open source
3. NHS England. Independent review of Major Trauma Networks reveals increase in patient survival rates. 25 June 2013. Records London's earlier launch and the April 2012 England-wide rollout.
england.nhs.uk - open source
4. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. New England Journal of Medicine. 2006;354:366-378. doi:10.1056/NEJMsa052049.
pubmed.ncbi.nlm.nih.gov - open source
5. Moran CG, Lecky F, Bouamra O, et al. Changing the System - Major Trauma Patients and Their Outcomes in the NHS (England) 2008-17. EClinicalMedicine. 2018;2-3:13-21. doi:10.1016/j.eclinm.2018.07.001.
pmc.ncbi.nlm.nih.gov - open source
6. American College of Surgeons. Advanced Trauma Life Support, 11th edition: programme update. 2025.
facs.org - open source
7. National Institute for Health and Care Excellence. Major trauma: assessment and initial management. NICE guideline NG39. Recommendations, especially imaging, haemorrhage management and damage-control surgery.
nice.org.uk - open source
8. American College of Surgeons. Advanced Surgical Skills for Exposure in Trauma (ASSET), 2nd edition. Course description.
learning.facs.org - open source
9. International Association for Trauma Surgery and Intensive Care. Definitive Surgical Trauma Care: introduction.
iatsic.org - open source

References continued

Clinical sources and historical evidence

10. Smyth L, Bendinelli C, Lee N, et al. WSES guidelines on blunt and penetrating bowel injury: diagnosis, investigations, and treatment. *World Journal of Emergency Surgery*. 2022;17:13. doi:10.1186/s13017-022-00418-y.

link.springer.com - open source

11. British Orthopaedic Association. BOAST: Open Fractures. December 2017.

boa.ac.uk - open source

12. Brain Trauma Foundation. Guidelines for the Surgical Management of TBI; and Guidelines for the Management of Severe TBI, 4th edition. Surgical indications and intracranial pressure monitoring.

braintrauma.org - open source | braintrauma.org (additional guideline) - open source

13. Rossaint R, Afshari A, Bouillon B, et al. The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition. *Critical Care*. 2023;27:80. doi:10.1186/s13054-023-04327-7.

link.springer.com - open source

14. German Society of Anaesthesiology and Intensive Care Medicine. Intraoperative haemodynamic monitoring and management of adults having non-cardiac surgery. *Journal of Clinical Monitoring and Computing*. 2024. doi:10.1007/s10877-024-01132-7. Used for the limitations of static CVP, not as a trauma-specific protocol.

link.springer.com - open source

15. Royal Cornwall Hospitals NHS Trust. Trauma Tertiary Survey (TTS): Standard Operating Procedure. March 2026. A current NHS operational example; local pathways may differ.

doclibrary-rcht.cornwall.nhs.uk - open source

16. Defence Medical Command. Clinical Guidelines for Operations: Orbital Compartment Syndrome. Used for the time-critical need for orbital decompression.

cgo.mod.uk - open source

17. NHS Borders. Nasal Fractures. Right Decisions clinical guidance. Septal haematoma assessment and urgent drainage.

rightdecisions.scot.nhs.uk - open source

Author biography sources

Professional homepage: About and Professional Record pages, consulted 13 October 2026. Academic and Clinical CV, August 2026, supplied through the author's Google Drive.

peymanorthopaedics.world/about/
peymanorthopaedics.world/professional-record/

CHAPTER ONE

Early care in major trauma

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

The first task in major trauma care is to preserve life while keeping open the possibility of meaningful recovery. This requires more than the correction of visible injuries. We must restore physiological stability, recognise injuries that cannot wait, and decide how much treatment the patient can safely tolerate at each stage. This chapter examines early resuscitation and the choice between definitive fixation and staged surgery, with particular attention to the multiply injured patient.

My central argument is that the extent of surgery should follow the patient's physiological capacity. A well-equipped hospital and an experienced surgeon make treatment possible; they do not, by themselves, make a prolonged operation appropriate. Equally, once a patient has recovered sufficiently, avoidable delay can become an obstacle to recovery. The responsibility of the trauma team is to recognise both situations and act on the evidence available at that moment.

From fracture treatment to organised trauma care

Modern trauma care developed through successive advances before, during and after the Second World War. Anaesthesia, asepsis, antimicrobial treatment, blood transfusion and organised transport made increasingly ambitious surgery possible. These developments were cumulative. They cannot be attributed to one organisation or one country, and their value depended on bringing them together around the injured patient.

An important orthopaedic milestone was the founding of the Arbeitsgemeinschaft für Osteosynthesefragen, or AO, by Swiss surgeons in 1958, after the war. AO helped standardise internal fracture fixation and its teaching. The historical lesson is broader than the introduction of plates and screws: reliable methods must be supported by training, documentation and a willingness to examine results. [1]

The operating environment also matters, but improvements should be described accurately. Sterility, appropriate antibiotic prophylaxis and infection prevention support safe surgery. Laminar airflow and airborne particle control should not be presented as independently proven explanations for declining major trauma mortality. WHO's surgical-site infection guidance does not establish such a mortality benefit; its specific recommendation against using laminar airflow solely to reduce infection in total arthroplasty should not be confused with a general judgment on trauma theatre design. [2]

For the trauma surgeon, technological progress changes what can be done. Clinical judgment determines what should be done now. That distinction runs through the development of early total care, damage control orthopaedics and contemporary approaches to definitive surgery.

The trauma centre as a coordinated system

A major trauma centre is useful because it brings capabilities together in time. Prehospital recognition, an accurate handover, immediate team activation, available blood, anaesthetic expertise, imaging, surgical access and critical care must operate as a connected service. A helipad is one part of this arrangement; the route from that helipad to resuscitation, theatre and intensive care is equally important.

The reorganisation of trauma networks across England began in April 2012, following the earlier London network. Leeds opened its major trauma centre in April 2013. These dates describe different stages of the same development and should not be used interchangeably. Leeds's published account describes an integrated helipad and dedicated lift connecting emergency care, operating theatres and critical care. [3,4]

Training in basic and advanced life support contributes to a shared foundation, while trauma-specific education addresses the priorities of injury. The surgeon's work depends on ambulance clinicians, emergency physicians, anaesthetists, radiologists, nurses, transfusion staff, therapists and others being able to act together. In this sense, centralisation is a commitment to reliable access to expertise, rather than simply the concentration of beds.

The Formula One analogy is helpful when explaining preparation and coordination. Every team member needs a role; equipment must be ready before arrival; information must reach the person who can act on it. The analogy has limits. Human physiology is variable, and the patient's priorities, dignity and future function remain part of every decision.

What mortality figures can tell us

The evidence supports organised trauma systems, but it does not support a universal claim that major trauma mortality has fallen from 25% to 7–9%. Such a comparison requires the same eligibility criteria, injury severity, age distribution, follow-up and handling of transfers. An all-injury registry, an intensive-care cohort and a cohort restricted to severe anatomical injuries will produce different crude rates.

In the English study by Moran and colleagues, 110,863 patients with ISS of at least 9 were treated at 35 consistently reporting hospitals during 2008–2017. There were 10,247 deaths, a crude mortality of 9.2%. The study found a 19% increase in the adjusted odds of survival over the nine-year study period, with a 95% confidence interval of 3–36%, while unadjusted mortality did not change significantly. This is evidence of improvement associated with system reorganisation; it is neither a 19 percentage-point survival gain nor a current national mortality estimate. [3]

Table 1 separates current reporting from historical evidence. NHS England re-established TARN as the National Major Trauma Registry, or NMTR, in 2024. A current, publicly verifiable national NMTR aggregate mortality rate was not identified for this chapter. [5]

Table 1 Selected mortality evidence available on 13 October 2026

Source and period	Reported outcome	Cohort and interpretation
England TARN 2008–2017 [3]	9.2% crude mortality 10,247 / 110,863	ISS ≥ 9 ; 35 consistently reporting hospitals. Death by discharge or 30 days, whichever occurred first. Historical study, not a current NMTR rate.
Leeds Ten-year report 2023 [4]	92.5% overall survival	More than 16,000 seriously injured patients over ten years. Exact eligibility, mortality timepoint and risk adjustment not supplied.
SweTrau 2025 data [6]	15.0% dead at acute-care discharge	NISS >15 , excluding patients transferred between hospitals; Table 8. Subgroup denominator not supplied in that table. Crude discharge outcome, not 30-day mortality.
TraumaRegister DGU 2025 data [7]	13.1% in-hospital mortality 3,739 / 28,617 RISC III expected 13.3%	Primary admissions in the basic group; excludes transfers in and early transfers out. Basic group: MAIS ≥ 3 , or MAIS 2 with ICU treatment or death; age documented. Multinational participating centres.

These rows should not be read as a league table. Risk adjustment and consistent follow-up are needed before comparing services. The DGU figure is drawn from a registry led by the German trauma society but includes participating hospitals outside Germany. The Swedish discharge outcome is not the same endpoint as 30-day mortality. Its updated report contains sections with different extraction dates, so an overall registration count has deliberately not been assigned to the mortality subgroup. [6,7]

At Leeds, where I practise, the ten-year institutional report recorded 92.5% overall survival. This is an encouraging account of the service, but it does not establish mortality lower than comparable centres because the publication does not supply the necessary cohort definition, endpoint or adjustment. The most useful expression of confidence in a trauma system is a commitment to transparent audit and improvement. [4]

Describing injury and assessing the living patient

Anatomical severity and present physiological condition answer different questions. Injury scores help us describe what happened and compare outcomes. The primary survey identifies what threatens life now. Neither can replace the other.

The Injury Severity Score, or ISS, uses the squares of the highest Abbreviated Injury Scale injury grades in the three most severely affected body regions. The New Injury Severity Score, or NISS, instead uses the three most severe injuries regardless of region. Both generally require a sufficiently complete injury inventory, often assembled after imaging, surgery and record review. NISS can therefore capture multiple severe injuries in one region that ISS does not fully represent. [8,9]

ISS greater than 15 is commonly used to describe severe injury in research and audit, but it is not a threshold that must be calculated before initiating trauma care. Nor are major trauma and polytrauma

exact synonyms: one critical injury may constitute major trauma. The immediate response should reflect the suspected threat and the patient's condition.

The Glasgow Coma Scale, or GCS, is different. It is a bedside assessment used during early care and repeated over time. Eye, verbal and motor responses should be recorded separately, with the timing and relevant confounders. Sedation, paralysis, intoxication, language barriers and intubation can affect interpretation. A component that cannot be assessed should be identified as not testable, rather than silently treated as a measured minimum response. [10]

We should therefore resist describing ISS, NISS and GCS as three equivalent retrospective classifications. A completed injury score may clarify the severity of the original insult; a changing GCS may require immediate action.

The first assessment and resuscitation

ATLS provides a shared approach to recognising and treating immediate threats. Its current eleventh edition uses xABCDE, placing exsanguinating external haemorrhage before the familiar airway, breathing, circulation, disability and exposure sequence. Assessment and necessary treatment occur together, with reassessment after interventions or deterioration. [11]

Table 2 Primary survey priorities

Step	Priority	Purpose in early care
x	Exsanguinating haemorrhage	Recognise and control catastrophic external bleeding.
A	Airway	Establish and maintain a patent airway, with attention to cervical spine protection.
B	Breathing	Assess ventilation and oxygenation and treat immediate thoracic threats.
C	Circulation	Assess perfusion, identify haemorrhage and begin appropriate resuscitation and source control.
D	Disability	Assess neurological status, including GCS components and pupils.
E	Exposure and environment	Examine for additional injury while protecting temperature and dignity.

The sequence organises priorities; it should not prevent parallel work by a trained team. A life-threatening problem discovered during assessment must be addressed without waiting for a completed injury list. Once immediate threats are managed, the secondary survey and subsequent review seek additional injuries and establish a fuller history. Changes in condition require a return to the primary priorities. [11]

In suspected major haemorrhage, the early response includes rapid activation of the haemorrhage pathway and timely control of the bleeding source. NICE supports early tranexamic acid for active or suspected active bleeding and restricts its routine use after three hours from injury. Imaging should be

matched to the response to resuscitation: an unstable nonresponder must not have necessary haemorrhage control delayed by extensive diagnostic imaging. [16]

Damage control resuscitation accompanies, rather than substitutes for, source control. It includes appropriate blood-component or locally approved haemostatic resuscitation, repeated assessment of coagulation, prevention of hypothermia and attention to ionised calcium. Serial lactate measurements help assess the response. Resuscitation targets must account for associated injuries, particularly traumatic brain injury, where inadequate perfusion is especially hazardous. [17]

A satisfactory blood pressure at one moment does not close the assessment. The important question is whether improvement is sustained, what support is maintaining it, and whether bleeding or another physiological threat continues.

Education for different environments

Courses provide complementary skills; they are not injury-severity classifications and they do not represent mutually exclusive treatment philosophies. The correct abbreviation for Definitive Surgical Trauma Care is DSTC. ASSET means Advanced Surgical Skills for Exposure in Trauma. [12,13]

Table 3 Complementary trauma education

Programme	Full name	Principal emphasis
ATLS [11]	Advanced Trauma Life Support	Initial assessment and treatment priorities.
DSTC [12]	Definitive Surgical Trauma Care	Operative decision-making and surgical management of major trauma.
ASSET [13]	Advanced Surgical Skills for Exposure in Trauma	Anatomical exposure for control of life- or limb-threatening injuries, including vascular control.
ETC [14]	European Trauma Course	Technical and non-technical skills in a trauma team.
TCCC [15]	Tactical Combat Casualty Care	Casualty care adapted to tactical threats, resources and evacuation conditions.

The setting determines which skills must be immediately available. A civilian major trauma centre, a remote hospital and a deployed military team may face different evacuation times and resources. Nevertheless, the purpose remains the same: identify the immediate threat, provide effective treatment within the team's capability, and arrange the next stage of care. Course completion should lead to maintained competence, simulation and reflection within the service.

Early total care

Early total care developed around the benefits of early definitive stabilisation of major fractures in patients able to tolerate it. The classic randomised study by Bone and colleagues included 178 adults with femoral fractures. Among multiply injured patients, delayed stabilisation was associated with

more pulmonary complications and longer hospital and intensive-care stays. This supported timely fixation in suitable patients. [18]

The attraction is understandable. A stable skeleton can support nursing care and rehabilitation, and an effective definitive operation may avoid an additional procedure. But the term should not be interpreted as a requirement to repair every injury in one sitting or as a promise that the patient will walk the following day. Weight-bearing and mobilisation depend on the injury pattern, the reconstruction and the patient's overall condition.

The availability of a theatre and a technically capable surgeon is therefore only part of the decision. The operation also makes demands on the patient. Its expected duration, blood loss, positioning and physiological burden must be weighed against its immediate benefit. The question is not how much the team can accomplish on the radiographs, but how much treatment will help this patient safely progress.

Damage control surgery and orthopaedics

Damage control limits the initial intervention to what is needed to address urgent threats and permit physiological recovery. It is active treatment with a planned next stage. In general trauma surgery, this may mean abbreviated control of haemorrhage and contamination; in orthopaedics, it may mean provisional stabilisation and essential treatment of threatened tissues before later reconstruction.

The European bleeding guideline supports damage control surgery in severe injury with haemorrhagic shock, continuing bleeding or coagulopathy. Hypothermia, acidosis and an excessively long required procedure are further reasons to abbreviate the initial intervention. The patient does not have to be in extremis before a staged approach becomes appropriate. [17]

The potential harm of an excessive early operative burden is supported by clinical evidence. In a multicentre randomised study of femoral shaft fractures, Pape and colleagues found increased acute lung injury after initial intramedullary nailing in a subgroup classified as borderline, compared with initial external fixation. This subgroup result supports selection and caution; it does not establish that all multiply injured patients require external fixation. [19]

The expression “do as little as possible, as quickly as possible” needs one qualification: do enough to achieve the necessary immediate objective. An abbreviated procedure that fails to control the threat has not achieved damage control. Conversely, an additional nonessential reconstruction can defeat the purpose of the strategy.

Staging also creates responsibilities. The team must specify what remains untreated, what physiological improvement is sought, who will reassess the patient and how the next operation will be prioritised. A temporary solution should not become an indefinite delay simply because the immediate crisis has passed.

Early appropriate care and safe definitive surgery

Early appropriate care, or EAC, makes readiness for early definitive fixation dependent on the response to resuscitation. It is a decision framework, not a separate operation for patients whose physiology remains substantially impaired.

In Vallier and colleagues' prospective EAC protocol, definitive fixation of selected femoral, pelvic, acetabular and spinal injuries was proposed within 36 hours when acidosis improved to at least one of the following: lactate below 4.0 mmol/L, pH at least 7.25, or base excess at least -5.5 mmol/L. Patients also had to be responding to resuscitation without vasopressor support. The original biochemical rule used "or", not "and". Persistent acidosis favoured damage control where feasible. [20]

The study included 335 patients and reported complications in 16.3% of those treated within 36 hours versus 33.3% after delay. This was not a randomised comparison, and all included patients achieved the biochemical targets within 36 hours. It should not be extrapolated to justify definitive fixation in persistent shock. [20]

Base excess is a calculated acid–base measure, not another name for pH. A more negative value indicates a greater metabolic base deficit. The EAC threshold must retain its negative sign: base excess -8 mmol/L does not satisfy a threshold of at least -5.5 mmol/L. When laboratories report base deficit instead, the convention must be checked before applying a criterion.

Safe definitive surgery, or SDS, emphasises repeated assessment and adjustment of the operative plan. The initial strategy can change as resuscitation succeeds or as the patient deteriorates. EAC and SDS share the intention of allowing timely definitive care while avoiding an excessive operative burden, although their proposed assessment frameworks are not identical. [21]

Contemporary SDS discussions assess shock, coagulation, temperature and associated tissue injury together. They also consider the surgical burden and the response during treatment. These are expert frameworks informed by a developing evidence base, rather than a universally validated numerical permission to operate. A lactate below 4 mmol/L is not, by itself, proof that an extensive operation is safe. [22]

Choosing the operation the patient can tolerate

The decision is best expressed as a provisional plan with conditions. What threatens life or limb immediately? What benefit will the proposed procedure provide now? What burden will it impose? What would make us shorten or stop it? These questions make the reasoning visible to the whole team.

Table 4 Linking the operative plan to the clinical trajectory

Clinical trajectory	Likely direction	Condition that must remain under review
Stable or adequately resuscitated	Consider early definitive treatment within an EAC or SDS approach.	Associated injuries and the anticipated burden of each procedure.
Improving but incompletely resolved concerns	Individualise the sequence; shorten or stage treatment where needed.	Whether improvement is sustained and sufficient for the proposed operation.
Persistent instability or deterioration	Urgent source control and damage control treatment where indicated.	Uncontrolled bleeding and the need for continued resuscitation.

Clinical trajectory	Likely direction	Condition that must remain under review
Recovery after damage control	Reassess for conversion to definitive treatment.	Physiological recovery, soft tissues and readiness of the multidisciplinary team.

This approach is consistent with NICE guidance: unstable patients who do not respond to resuscitation should undergo damage control surgery; definitive surgery may be considered in those who respond; patients with normal haemodynamics may proceed to definitive treatment where indicated. These are broad surgical principles, not instructions to disregard associated injuries or the scale of a particular operation. [16]

A patient may appropriately receive definitive treatment for one injury and provisional treatment for another. The classification belongs to the decision at that time, rather than permanently to the person. Intraoperative reassessment is therefore essential: the plan agreed at the beginning is not an obligation to finish every proposed procedure if the condition changes. [21]

An improving lactate should be read alongside respiratory function, coagulation, temperature and the neurological situation. Major chest injury or brain injury can alter the tolerance of surgery even when a metabolic criterion has been reached. These considerations help explain why a single laboratory threshold cannot replace multidisciplinary judgment. [22]

Orthopaedic priorities within the whole patient

The orthopaedic surgeon must distinguish injuries that threaten life or limb from those whose definitive reconstruction can wait. A vascular injury, compartment syndrome, open fracture or threatened soft-tissue envelope may require urgent action despite the need to limit the overall operative burden.

Open fractures require prompt intravenous antibiotic prophylaxis, protection of the wound and a coordinated plan for debridement, fixation and soft-tissue management. Suspected vascular compromise requires urgent assessment and treatment; necessary revascularisation must not be delayed for routine imaging. Documented neurovascular examinations and repeated assessment for compartment syndrome remain important throughout early care. NICE's complex-fracture guidance supplies injury-specific recommendations that should accompany the general resuscitation framework. [23]

For pelvic trauma, stabilisation, bleeding control and definitive reconstruction are related but different objectives. The appropriate sequence depends on physiology, the suspected source of bleeding and the available multidisciplinary expertise. A technically satisfactory fracture construct cannot compensate for uncontrolled haemorrhage elsewhere.

It is also necessary to preserve future options. Provisional treatment should be planned with the later reconstruction in mind. The first operation is part of a course of care, and its success should be judged partly by whether it makes the subsequent stages safer and more achievable.

Three illustrations of the decision

The following examples are hypothetical teaching scenarios, not reports of individual patients or substitutes for a full assessment.

First, a patient with major fractures has responded to resuscitation, has a falling lactate, stable circulation without vasopressor support, satisfactory coagulation and temperature, and no overriding respiratory or neurological concern. The team may plan early definitive fixation, with the sequence and stopping conditions agreed beforehand. The aim is to use recovered physiological capacity productively.

Second, a patient has a lactate of 3.2 mmol/L but worsening oxygenation, hypothermia and an increasing transfusion requirement. The lactate alone does not establish readiness for prolonged definitive fixation. Continued resuscitation, investigation and control of the remaining threat take priority; an abbreviated orthopaedic strategy may be appropriate.

Third, a patient has persistent haemorrhagic shock and an unstable fracture. Urgent haemorrhage control and necessary provisional stabilisation cannot wait for a normal lactate. In this situation, restoration of physiology is the immediate objective of treatment, not a condition that must first be achieved before any intervention.

The difference between these examples is the patient's trajectory and the purpose of the proposed operation. This is the practical meaning of matching treatment to physiology.

Reassessment and the beginning of recovery

Early care continues after the first procedure. The handover must explain the injuries identified, what has been treated, remaining threats, physiological trends and the agreed next steps. A repeat examination and review of investigations help identify injuries obscured by the initial emergency. The plan for return to theatre must remain visible through changes of staff and location.

Recovery also needs a place in the early discussion. NICE recommends assessing rehabilitation needs after traumatic injury and coordinating physical, cognitive and psychological care. Pain control, communication, mobility planning and patient involvement should develop alongside acute treatment as the condition permits. [24]

Survival is the first outcome we seek, but it is not the only outcome that matters. The patient will later judge treatment through function, independence, pain and participation in ordinary life. Early decisions should preserve the possibility of those outcomes, even when the immediate circumstances allow only a limited intervention.

My philosophy of early care is therefore one of proportionate action. We should be decisive when a threat requires treatment, restrained when the patient cannot tolerate a larger intervention, and ready to proceed when recovery makes definitive care appropriate. The strongest trauma service is one that can do all three, explain its decisions and learn from its results.

References

Sources checked on 13 October 2026. Report years and injury years are distinguished in Table 1. The clinical discussion concerns professional decision-making; detailed procedural and resuscitation protocols remain injury- and setting-specific.

1. AO Foundation. AO archive and history. Founding of AO in 1958. [Source](#)
2. World Health Organization. Global guidelines for the prevention of surgical site infection. 2nd ed. 2018. Section 4.23 on laminar airflow. [Source](#)
3. Moran CG, Lecky F, Bouamra O, et al. Changing the System—Major Trauma Patients and Their Outcomes in the NHS (England) 2008–17. *EClinicalMedicine*. 2018;2–3:13–21. doi:10.1016/j.eclinm.2018.07.001. [Source](#)
4. Leeds Teaching Hospitals NHS Trust. Leeds Major Trauma Centre marks 10 years of saving lives in region. 19 April 2023. [Source](#)
5. NHS England. National Major Trauma Registry. Registry re-established from TARN in 2024. [Source](#)
6. SweTrau. Årsrapport 2025. Dated 20 May 2026; updated 8 October 2026. Inclusion criteria p 4; acute-care discharge outcomes Table 8, p 24. Updated sections use an October extraction; some other sections retain earlier data. [Source](#)
7. Sektion NIS of DGU and ITF of AUC. TraumaRegister DGU General Annual Report 2026. Data for 2025. Basic group pp 6–7; mortality and RISC III prognosis p 8; participating countries p 52. [Source](#)
8. Baker SP, O'Neill B, Haddon W Jr, Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*. 1974;14:187–196. [Source](#)
9. Osler T, Baker SP, Long W. A modification of the injury severity score that both improves accuracy and simplifies scoring. *J Trauma*. 1997;43:922–925; discussion 925–926. doi:10.1097/00005373-199712000-00009. [Source](#)
10. Glasgow Coma Scale. Recording the GCS and assessment resources. [Source](#)
11. American College of Surgeons. About Advanced Trauma Life Support. Eleventh-edition xABCDE framework. [Source](#)
12. Definitive Surgical Trauma Care course. Programme information. [Source](#)
13. American College of Surgeons. Advanced Surgical Skills for Exposure in Trauma. Course information. [Source](#)
14. European Trauma Course. Course information and team approach. [Source](#)
15. Joint Trauma System. Committee on Tactical Combat Casualty Care. Programme and guidance resources. [Source](#)
16. National Institute for Health and Care Excellence. Major trauma: assessment and initial management. NG39. 2016. Recommendations, including 1.5.37–1.5.39. [Source](#)
17. Rossaint R, Afshari A, Bouillon B, et al. The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition. *Critical Care*. 2023;27:80. doi:10.1186/s13054-023-04327-7. [Source](#)
18. Bone LB, Johnson KD, Weigelt J, Scheinberg R. Early versus delayed stabilization of femoral fractures. A prospective randomized study. *J Bone Joint Surg Am*. 1989;71:336–340. doi:10.2106/00004623-198971030-00004. [Source](#)
19. Pape HC, Rixen D, Morley J, et al. Impact of the method of initial stabilization for femoral shaft fractures in patients with multiple injuries at risk for complications (borderline patients). *Ann Surg*. 2007;246:491–499. doi:10.1097/SLA.0b013e3181485750. [Source](#)

20. Vallier HA, Moore TA, Como JJ, et al. Complications are reduced with a protocol to standardize timing of fixation based on response to resuscitation. *J Orthop Surg Res.* 2015;10:155. doi:10.1186/s13018-015-0298-1. [Source](#)
21. Pape HC, Pfeifer R. Safe definitive orthopaedic surgery (SDS): repeated assessment for tapered application of Early Definitive Care and Damage Control? *Injury.* 2015;46:1–3. doi:10.1016/j.injury.2014.12.001. Editorial framework. [Source](#)
22. Fracture fixation in polytraumatized patients—From an interdisciplinary early total/appropriate care to the safe definitive surgery concept. *Front Med.* 2024;11:1362986. doi:10.3389/fmed.2024.1362986. Expert review. [Source](#)
23. National Institute for Health and Care Excellence. Fractures (complex): assessment and management. NG37. Recommendations. [Source](#)
24. National Institute for Health and Care Excellence. Rehabilitation after traumatic injury. NG211. 2022. Recommendations. [Source](#)

CHAPTER 2

Head and Neck Injuries

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

Head and neck injuries can threaten the airway, interrupt ventilation, cause major haemorrhage and damage the brain or spinal cord. We must consider them throughout the primary survey. A striking facial injury may draw our attention, but the immediate priority is its physiological effect and the threat to life or function.

My approach is to consider these injuries within the whole patient. Securing an airway protects the brain; controlling bleeding supports cerebral perfusion. Cervical protection must remain compatible with oxygenation. The major trauma consultant coordinates these connected decisions and brings the appropriate specialists to the patient.

This chapter covers initial assessment and early management in adult polytrauma, using ABCDE and an injury checklist for repeated surveys. Children require age-specific airway, imaging and physiological pathways.

Head and neck injuries through ABCDE

Where catastrophic external bleeding is present, control it immediately while airway care proceeds. ABCDE remains a repeated assessment: deterioration in consciousness, increasing swelling or renewed bleeding requires a return to the relevant earlier step. Anatomical classification helps describe an injury, but does not determine its priority by itself. [1,2]

Stage	Threat to recognise	Clinical priority
A	Airway obstruction or loss of protection	Clear obstruction, support oxygenation and plan a secure airway while protecting the cervical spine.
B	Failure of ventilation or oxygenation	Assess ventilation and oxygenation; consider aspiration, airway disruption, cord and chest injury.
C	External or concealed haemorrhage	Control bleeding and assess scalp, face and major neck vessels; activate haemorrhage care.
D	Brain, cord or cerebral vascular injury	Record GCS components, pupils and limb findings; escalate deterioration, focal deficits or seizures.
E	Missed injuries and heat loss	Inspect scalp, face, ears, mouth, neck and concealed wounds; complete examination and prevent heat loss.

Airway and ventilation

Facial trauma threatens the airway through bleeding, tissue swelling, displaced bone and loss of muscular support. Bilateral anterior mandibular fractures may allow the tongue-bearing segment to fall backwards. A mobile or displaced midface may narrow the upper airway, and teeth or bone fragments may be aspirated. Airway assessment and suction take priority over a detailed fracture classification. [3]

Le Fort describes three classical patterns of midface fracture. Real injuries may be asymmetric, comminuted or combine several patterns. The airway decision follows the clinical findings and anticipated deterioration, not simply whether a fracture is labelled I, II or III. [4]

Pattern	Anatomical description	Relevance during early care
Le Fort I	Horizontal separation of the tooth-bearing maxilla and palate from the upper midface.	Assess oral bleeding, mobility, occlusion and displaced fragments.
Le Fort II	Pyramidal midface injury involving the nasal bridge, medial orbit and infraorbital region.	Assess airway, eyes and associated skull-base or vascular injury.
Le Fort III	Separation of the midface from the cranial base, or craniofacial disjunction.	Anticipate complex airway management and associated intracranial, orbital and vascular injury.

Anaesthesia and airway expertise should be involved early when there is obstruction, impaired airway protection or progressive swelling. Suspected skull-base or severe midface injury is a reason to avoid blind nasal instrumentation. Prepare a rescue airway plan before repeated attempts worsen bleeding or swelling. Cervical protection must not obstruct essential airway treatment. [3]

A fracture that obstructs the upper airway remains an A problem even when hypoxia is detected during B. The breathing assessment also looks for aspirated material, associated chest injury and ventilatory weakness from high cervical cord injury. Hoarseness, stridor, haemoptysis or surgical emphysema after neck trauma should prompt urgent concern for laryngeal or tracheal injury. A distorted airway needs a senior anaesthetic and ENT plan, including surgical airway capability. [5]

Haemorrhage and vascular injury

The scalp and face can bleed substantially, and major neck vessel injury may produce exsanguination or an expanding haematoma that threatens the airway. External appearance can underestimate blood loss. Persistent bleeding is harder to control when hypothermia, acidosis and coagulopathy develop; haemorrhage control and resuscitation must proceed together. [2]

Use direct pressure where anatomically appropriate and avoid blind clamping or exploration of a neck wound. Haemodynamic instability, uncontrolled haemorrhage or rapidly expanding neck swelling demands immediate senior operative assessment. A stable patient can undergo CT angiography to define the vascular injury and plan treatment. Imaging must not postpone a lifesaving intervention. [5]

Exposure of the distal internal carotid artery near the skull base is difficult because the mandible and adjacent structures restrict access. The thoracic inlet also presents substantial challenges and may

require an extended approach. The carotid sheath, jugular vein, cranial nerves, airway and oesophagus need consideration; the vertebral artery has additional protection and access constraints within the cervical transverse foramina. Operative, endovascular or combined treatment depends on the injury and available expertise. [5]

Carotid and vertebral injuries can also cause dissection, thrombosis, pseudoaneurysm or embolic stroke without major external bleeding. Use the local blunt cerebrovascular injury screening pathway, particularly with high-risk cervical, skull-base or severe midface injuries, or an unexplained neurological deficit. Once injury is confirmed, antithrombotic treatment is considered as early as safely possible through a joint trauma, neurosurgical and vascular decision. Active intracranial bleeding affects that balance. Routine stenting is not appropriate for every lesion. [6]

Brain injury and neurological deterioration

Primary traumatic brain injury occurs at impact through direct deformation, acceleration, deceleration, rotation or penetration. These mechanisms can cause contusion, laceration, vascular disruption and diffuse axonal injury. Diffuse axonal injury involves axonal stretching and disruption, with microscopic injury that may be extensive even when initial CT findings are limited. [7]

Secondary injury develops through processes such as impaired perfusion, hypoxia, oedema and biochemical disturbance. An intracranial haematoma may begin at impact and then expand, producing additional compression and ischaemia. Primary injury and secondary deterioration therefore overlap. The purpose of early care is to prevent avoidable physiological insults while identifying lesions that require intervention. [7]

Record the separate eye, verbal and motor components of the Glasgow Coma Scale, pupil size and reactivity, limb movement and any lateralising signs. Record the time and confounders such as sedation, intubation or intoxication. Serial trends are essential, but severe initial impairment, a new focal deficit or abnormal pupils can independently demand immediate escalation. Severe impairment of consciousness also requires an airway decision. [8]

Urgent non-contrast CT identifies haemorrhage, fractures and mass effect. Apply NICE NG232 imaging criteria, including the one-hour pathway for high-risk adult findings such as marked GCS impairment, suspected open or depressed fracture, basal skull signs, post-traumatic seizure or a focal deficit. Repeat examination and escalate new deterioration even after earlier imaging. CT may underestimate axonal injury; MRI can clarify persistent unexplained neurological dysfunction once the patient is stable. [1,8]

Intracranial bleeding and protection of the injured brain

Extradural, acute subdural and intraparenchymal haematomas can create mass effect, obstruct cerebrospinal fluid pathways and cause herniation. The neurosurgical decision combines the lesion, neurological examination, change over time and intracranial pressure. An abnormal scan does not mean that every patient needs a craniotomy. Conversely, deterioration must not wait for a predetermined size threshold. [10]

Established Brain Trauma Foundation criteria include evacuation of an extradural haematoma exceeding 30 cm³, and an acute subdural haematoma thicker than 10 mm or causing more than 5 mm of midline

shift. Smaller lesions may still need surgery when the patient deteriorates or shows other concerning findings. Selected stable lesions can be monitored with specialist observation and serial imaging. [10]

Craniotomy allows access to evacuate a clot and control bleeding, with replacement of the bone flap when appropriate. Decompressive craniectomy leaves the flap off to accommodate swelling. It is a selected neurosurgical intervention whose timing, expected benefit and consequences for survival and disability require specialist judgment. [8,10]

Avoid hypoxia and hypotension. In adult TBI, ACS guidance gives initial targets of oxygen saturation at least 94%, PaCO₂ 35–45 mmHg in the absence of intracranial hypertension, and systolic pressure at least 110 mmHg; targets need individualisation. The resuscitation plan must protect cerebral perfusion while controlling extracranial bleeding. [8]

Raised intracranial pressure may require sedation, hyperosmolar therapy, cerebrospinal fluid drainage or surgery within a neurocritical care pathway. Prolonged prophylactic hyperventilation is harmful; a brief specialist-directed reduction in carbon dioxide may be used as a bridge during impending herniation. Corticosteroids must not be used to treat traumatic cerebral oedema. Seizures require prompt treatment, with prophylaxis considered according to injury risk and protocol. [9]

Cervical spine and spinal cord injury

Cervical fractures, dislocations and ligament disruption may accompany head and facial trauma. Maintain appropriate spinal motion restriction while completing resuscitation. Pain may be absent or impossible to assess in an unconscious, intoxicated or multiply injured patient. A normal limb examination does not by itself exclude an unstable injury. [11]

CT is the principal initial investigation for suspected adult cervical spine injury when indicated. If neurological abnormality could arise from cord injury, NICE recommends MRI after CT even when CT does not show the cause. Seek urgent spinal surgical advice for instability or neurological deficit. High cervical injury can impair ventilation. Neurogenic shock is a consideration after cord injury, but haemorrhage and other causes of shock must be actively excluded. [11]

Orbital and ocular emergencies

Bleeding behind the globe can raise orbital pressure and compromise retinal and optic nerve perfusion. Orbital compartment syndrome may present with proptosis, reduced vision, a relative afferent pupillary defect, restricted eye movements and a tense orbit. A sedated patient cannot report visual loss, so examination is particularly important. [12]

When orbital compartment syndrome is clinically evident, urgent decompression by a trained clinician must not be delayed for CT or the arrival of an ophthalmologist. The emergency procedure is lateral canthotomy with inferior cantholysis; canthotomy alone may not adequately release pressure. Urgent ophthalmology input and reassessment remain essential. [12]

Suspected open globe injury requires a protective rigid shield without pressure and urgent ophthalmic assessment. Avoid pressure-based examination, including tonometry when globe rupture is suspected. Do not remove an embedded foreign body. Reduced vision may also reflect intraocular bleeding, retinal injury or optic nerve injury. Orbital fractures with muscle entrapment, particularly a trapdoor injury in a

child, require urgent specialist assessment; nausea or bradycardia may accompany an oculocardiac reflex. [13,15]

Nasal and other aerodigestive injuries

A nasal septal haematoma separates the cartilage from its nourishing mucoperichondrium. Examine the septum after nasal injury: obstruction and a soft septal swelling should prompt urgent ENT or maxillofacial assessment. Drainage is required promptly to prevent cartilage necrosis, abscess and later deformity. An apparently simple nasal fracture must not distract from this emergency. [14]

Severe epistaxis can obstruct the airway or cause significant blood loss and may require specialist haemostasis. Clear nasal or ear discharge after trauma raises concern for a skull-base injury and cerebrospinal fluid leak. Temporal bone injury may also affect hearing, balance or facial nerve function. These findings need documentation and appropriate neurosurgical or ENT review. [1,14]

Penetrating neck wounds can injure the pharynx or oesophagus as well as major vessels and airway structures. Dysphagia, odynophagia, haematemesis or emphysema should prompt targeted assessment. In a stable patient, CT angiography is central to evaluation but additional endoscopic or contrast studies may be needed when the wound trajectory or symptoms suggest an aerodigestive injury. Missed perforation risks deep infection. [5]

Coordinating specialist care

The trauma team leader must make the treatment sequence explicit when priorities compete. Anaesthesia and critical care support the airway and physiological control. Neurosurgery addresses intracranial injury; spinal surgeons address instability and cord compression. Oral and maxillofacial surgery manages facial skeletal injury, while ENT contributes to laryngeal, pharyngeal, nasal and otological problems. Ophthalmology is essential for injuries threatening vision. Vascular surgery and interventional radiology guide vascular control, with cardiothoracic support when the injury extends to the thoracic inlet or chest. Plastic surgery contributes to complex soft-tissue repair and reconstruction.

Consultations should run in parallel when needed, with a named clinician responsible for each outstanding decision. The handover should record neurological trends before and after sedation, pupil and visual findings, airway difficulty, haemorrhage control, vascular concerns, cervical spine status, imaging results and the next planned reassessment. The tertiary survey revisits injuries that could not be assessed reliably during resuscitation.

For the major trauma consultant, the central responsibility is to keep these decisions connected. A technically successful intervention has limited value if the patient deteriorates while another urgent injury remains unrecognised. Early care should preserve life while protecting the possibility of neurological recovery, vision, communication, swallowing and later reconstruction.

Head and neck injury checklist for polytrauma

Use this list during repeated assessment, imaging review and handover. 'Immediate' means treatment or specialist escalation during resuscitation. 'Urgent' means assessment in the early trauma episode without avoidable delay; it does not mean that every injury requires an operation. The patient's physiology and evolving findings can raise the priority of any item. [1–15]

Injury or condition	Priority	Action or specialist assessment
Airway obstruction from blood, teeth, swelling or displaced facial structures	Immediate	Suction, oxygenation and definitive airway plan; anaesthesia with ENT or maxillofacial support.
Laryngeal fracture or laryngotracheal disruption	Immediate if threatened	Recognise stridor, voice change and emphysema; senior airway and ENT assessment.
Expanding neck haematoma or active major vessel bleeding	Immediate	Coordinate airway protection, haemorrhage resuscitation and operative or endovascular control.
Major scalp, facial or nasal haemorrhage	Immediate if ongoing	Control bleeding and reassess circulatory impact; involve the relevant surgical team.
Carotid or vertebral dissection, thrombosis or pseudoaneurysm	Immediate if new deficit or active bleeding; urgent otherwise	CT angiography when indicated; assess stroke risk and safe antithrombotic treatment.
Extradural or acute subdural haematoma	Immediate if deterioration or mass effect	Neurosurgical assessment for evacuation or closely monitored observation.
Cerebral contusion or intraparenchymal haematoma	Urgent or immediate if expanding	Serial examination and imaging; escalate mass effect or falling consciousness.
Traumatic subarachnoid or intraventricular haemorrhage	Urgent	Assess associated injury and hydrocephalus; neurosurgical monitoring plan.
Diffuse axonal injury or unexplained coma	Urgent	Prevent secondary injury; consider MRI after stabilisation and neurocritical care review.
Cerebral swelling, herniation or post-traumatic seizure	Immediate	Neuroresuscitation and urgent neurosurgical or critical care treatment.
Open, depressed or penetrating cranial injury	Urgent or immediate	Neurosurgical assessment; protect the wound and address contamination and dural injury.
Basal skull fracture or cerebrospinal fluid leak	Urgent	Neurosurgical and ENT review; avoid blind nasal instrumentation.
Cervical fracture, dislocation or ligament injury	Urgent	Maintain motion restriction, obtain indicated imaging and involve spinal surgery.

Injury or condition	Priority	Action or specialist assessment
Cervical cord injury or compressive spinal haematoma	Immediate specialist escalation	Assess ventilation and perfusion; urgent spinal imaging and surgical advice.
Orbital compartment syndrome	Immediate	Clinical diagnosis; trained clinician performs lateral canthotomy and inferior cantholysis.
Open globe or intraocular foreign body	Immediate eye protection and referral	Rigid shield without pressure; leave embedded objects in place and obtain urgent ophthalmic care.
Orbital fracture with extraocular muscle entrapment	Urgent	Ophthalmic and maxillofacial assessment; escalate oculocardiac symptoms.
Traumatic visual loss, hyphaema or suspected retinal or optic nerve injury	Urgent	Document vision and pupils; prompt ophthalmology assessment.
Nasal septal haematoma or abscess	Urgent	Prompt ENT or maxillofacial drainage pathway.
Le Fort, mandibular, zygomatic or naso-orbito-ethmoid fracture	Urgent after threats treated	Assess airway, bleeding, vision, occlusion and associated injuries before reconstruction.
Dental or dentoalveolar injury with missing teeth	Urgent	Account for teeth and possible aspiration; dental or maxillofacial assessment.
Pharyngeal or oesophageal perforation	Urgent	Targeted investigation and early surgical plan; consider infection risk.
Temporal bone injury with hearing loss or facial weakness	Urgent	Document cranial nerve and ear findings; ENT and neurosurgical review as indicated.
Complex facial or neck wounds and tissue loss	Urgent after resuscitation	Assess nerve, duct and vascular injury, contamination, tissue viability and reconstruction needs.

References

Sources checked on 13 October 2026. Numbers in the text refer to the sources below.

1. National Institute for Health and Care Excellence. Head injury assessment and early management. NICE NG232. 2023. Recommendations. [NICE guidance](#)
2. National Institute for Health and Care Excellence. Major trauma assessment and initial management. NICE NG39. 2016. Recommendations. [NICE guidance](#)
3. AO Foundation. AO Surgery Reference. Airway considerations in craniomaxillofacial trauma. [AO reference](#)
4. AO Foundation. AO Surgery Reference. Definitions of Le Fort I, II and III fractures. [Le Fort I](#) | [Le Fort II](#) | [Le Fort III](#)
5. Western Trauma Association. Penetrating neck trauma algorithm. Notes on resuscitation, exposure, imaging and aerodigestive assessment. [Note A](#) | [Note B](#) | [Note D](#) | [Note I](#)
6. Kim DY, Biffi W, Bokhari F, et al. Evaluation and management of blunt cerebrovascular injury. EAST practice management guideline. Journal of Trauma and Acute Care Surgery. 2020;88:875–887. [Published guideline](#)
7. National Institute of Neurological Disorders and Stroke. Traumatic Brain Injury. Information booklet on mechanisms and consequences. 2025. [NINDS booklet](#)
8. American College of Surgeons. Best Practices Guidelines in the Management of Traumatic Brain Injury. 2024. Assessment, imaging, directed care and surgical management. [ACS guideline](#)
9. Brain Trauma Foundation. Guidelines for the Management of Severe Traumatic Brain Injury. 4th edition. 2016. Ventilation, intracranial pressure and pharmacological treatment. [BTF guideline](#)
10. Brain Trauma Foundation. Guidelines for the Surgical Management of Traumatic Brain Injury. Operative indications for traumatic mass lesions. [BTF surgical guidance](#)
11. National Institute for Health and Care Excellence. Spinal injury assessment and initial management. NICE NG41. 2016. Recommendations. [NICE guidance](#)
12. American Academy of Ophthalmology. EyeWiki. Orbital Compartment Syndrome. Reviewed July 2026. [Clinical reference](#)
13. American Academy of Ophthalmology. EyeWiki. Pre Ophthalmologist Management of Eye Trauma. [Clinical reference](#)
14. Defence Medical Command. Clinical Guidelines for Operations. Nasal injuries. Reviewed 1 April 2026. [Operational guideline](#)
15. AO Foundation. AO Surgery Reference. Emergency treatment of midface and orbital trauma. [AO reference](#)

CHAPTER THREE

Thoracic injuries in major trauma

Mr Peyman Bakhshayesh, MD, PhD, MBA
Consultant Trauma and Orthopaedic Surgeon

The chest brings breathing and circulation into the same anatomical space. An injury may prevent air from entering the lungs, impair gas exchange, interrupt venous return or cause major internal bleeding. These processes often coexist. Our first responsibility is to identify which of them is threatening life and restore the conditions in which the patient can survive further assessment.

This chapter develops the anatomical and physiological foundations of chest trauma care, then follows the patient through assessment, emergency treatment, chest wall reconstruction and recovery. My approach is to begin with how the thorax works. When we understand the mechanism of failure, the purpose and timing of treatment become clearer.

The thorax as a moving protective structure

The thorax is broadly conical, narrower superiorly and wider inferiorly. Its skeleton comprises the sternum anteriorly, twelve pairs of ribs and their cartilages laterally, and the thoracic vertebrae posteriorly. The superior thoracic aperture is bounded by the first thoracic vertebra, first ribs and superior border of the manubrium. The clavicles and scapulae form the shoulder girdle around the upper chest; they are important neighbouring structures, but do not constitute the aperture itself.

Anteriorly, ribs one to seven attach to the sternum through their own costal cartilages. Ribs eight to ten join the cartilage above, while ribs eleven and twelve have no anterior sternal attachment. Posteriorly, the ribs articulate with the thoracic vertebrae. This arrangement combines protection with the movement necessary for ventilation.

The diaphragm closes the inferior thoracic aperture and separates the chest from the abdomen. Each lung occupies a pleural compartment. Between them, the mediastinum contains the heart and pericardium, great vessels, central airways and oesophagus. A lower chest wound may therefore involve abdominal organs, and a seemingly limited chest wall injury may accompany damage within the thorax.

Clinical scope: principles and decision-making for healthcare professionals, primarily in adult major trauma. Invasive procedures require appropriate training, facilities and current local protocols. References checked 13 October 2026.

Breathing mechanics and the consequences of injury

During spontaneous inspiration, the diaphragm contracts and descends. Rib movement increases the anteroposterior and transverse dimensions of the chest. The pump-handle and bucket-handle descriptions help explain these movements: the sternum moves forwards and upwards, while the ribs expand laterally. Intrathoracic pressure falls and air moves into the lungs. The two sides expand together, rather like wings opening, although their mechanics are linked through the chest wall and respiratory muscles.

Quiet expiration is largely passive. The inspiratory muscles relax and elastic recoil reduces lung and chest volume, allowing air to leave. Forced expiration additionally recruits abdominal and other expiratory muscles. The diaphragm therefore does not actively push air out during every ordinary breath. This distinction matters when explaining fatigue, pain-related splinting and the effects of mechanical ventilation.

Air in the pleural space can uncouple the lung from the expanding chest wall. Blood can occupy space needed for ventilation while simultaneously reducing circulating volume. Pain can make each breath shallow and coughing ineffective. A damaged lung may receive air but exchange oxygen poorly. Increased pleural pressure or pericardial pressure can obstruct cardiac filling. These are different mechanisms, and improvement in one does not establish that the others have resolved.

Mechanism guides suspicion

Blunt trauma transfers energy through compression, bending and deceleration. A direct blow may fracture ribs and contuse the lung beneath; rapid deceleration can injure structures at points of relative fixation. Penetrating trauma follows a track that may cross the pleura, lung, mediastinum or diaphragm. The visible wound gives an incomplete account of that track. We should avoid judging internal damage by the size of the skin opening.

Mechanism also helps explain why an apparently intact chest wall can conceal serious injury. A more compliant chest, particularly in a child, may transmit force without an obvious rib fracture. In an older adult, relatively modest trauma can produce several fractures and a substantial loss of respiratory reserve. Examination and physiological response remain essential in both situations.

A physiological assessment

After controlling catastrophic external haemorrhage, assess airway, breathing and circulation together. Observe speech, respiratory rate, depth, symmetry and effort. Examine for wounds, bruising, tenderness, deformity and subcutaneous emphysema; compare breath sounds and assess perfusion. Record oxygen delivery as well as saturation. A satisfactory saturation achieved with increasing oxygen does not mean that the patient is stable.

Repeat the assessment after every important intervention, transfer or change of ventilation. Ask whether breathing has become easier, whether circulation has improved and what remains unexplained. The trend often identifies failure earlier than an isolated observation.

Immediate threats and the role of imaging

The primary survey should lead directly to treatment when a reversible thoracic cause of collapse is suspected. A portable investigation is useful only if it answers an urgent question without delaying the intervention the patient needs.

Table 1 Immediate physiological priorities

Problem	Main physiological threat	Immediate treatment priority
Tension pneumothorax	Impaired ventilation and obstructed venous return	Urgent pleural decompression when clinically indicated
Open pneumothorax	Loss of effective ventilation through the injured chest wall	Manage the wound and pleural space with close reassessment
Major haemothorax	Blood loss with compression of the lung	Blood resuscitation, drainage and early haemorrhage control
Cardiac tamponade	Restricted cardiac filling	Immediate specialist assessment and operative relief when indicated
Severe lung or airway injury	Failure of oxygenation or ventilation	Secure effective ventilation and obtain specialist control

In adults with severe respiratory compromise, NICE supports immediate chest radiography and/or extended focused assessment with sonography for trauma (eFAST) during the primary survey. In adults without severe respiratory compromise who have normal haemodynamics or respond to resuscitation, consider immediate CT. Imaging should not hold up treatment of suspected tension pneumothorax causing haemodynamic instability or severe respiratory compromise. CT is not routinely the first investigation for chest trauma in children under sixteen. [1]

A negative bedside examination or ultrasound study must be interpreted within its limits. Neither accounts for every possible injury. CT can define the chest wall, pleural spaces, lung and mediastinum in far greater detail, but the team must decide whether the patient can tolerate the journey and the time required.

Pneumothorax

Tension pneumothorax is a physiological emergency, rather than a radiographic size category. It may develop rapidly after positive-pressure ventilation. Severe respiratory compromise or shock with compatible unilateral findings demands action; waiting for the complete classical picture can be dangerous. When expertise is available, NICE favours open thoracostomy over needle decompression, followed by a chest drain in a spontaneously breathing patient. [1]

For an open chest wound, use the professional trauma pathway for wound coverage, monitoring and pleural drainage. A seal can be followed by tension physiology if air cannot escape. Definitive drainage is normally established at a separate suitable site. Selected small pneumothoraces in stable patients can be observed only with a clear monitoring and rescue plan; deterioration changes that plan. [2]

Haemothorax and haemorrhage control

A haemothorax is both a respiratory problem and a potential explanation for shock. The volume visible on a scan or collected in a drainage system is only part of the assessment. Blood may remain clotted in the chest, drainage may be obstructed, and important bleeding may also be occurring elsewhere. The response to resuscitation must be interpreted alongside these findings.

Drainage should proceed alongside appropriate resuscitation and early surgical involvement. Persistent shock, transfusion requirement and suspected active intrathoracic bleeding justify urgent escalation. The WSES-AAST guideline lists chest tube blood loss exceeding 1,500 mL in 24 hours, or drainage exceeding 200 mL per hour for three consecutive hours, among prompts for surgery. These values support judgement; the team must not wait for a numerical threshold when physiology already demands haemorrhage control. A low drain output can be falsely reassuring. [2]

Blood component treatment, warming and correction of coagulopathy belong within the major haemorrhage protocol. The principle established in Chapter 1 applies here: the extent of the first operation must match the patient's physiological reserve. Definitive reconstruction may need to follow after bleeding is controlled and the patient has recovered sufficiently.

The chest drain as an ongoing responsibility

Insertion is the beginning of drain management. Record the side, indication, initial findings, ongoing blood loss, air leak and the patient's response. Secure the system, confirm its function and reassess position when progress is unexpected. A tube on an image does not prove that the pleural problem has been treated adequately.

Drain choice depends on the indication and physiological state. EAST conditionally supports pigtail catheters for selected stable patients with haemothorax requiring drainage. An unstable patient with major haemothorax requires emergency tube thoracostomy with an appropriately large drain. A retained haemothorax after initial drainage warrants prompt specialist assessment; EAST conditionally favours video-assisted thoracoscopic surgery (VATS) over fibrinolytic treatment and recommends early VATS, within four days, when indicated. The supporting evidence is limited. [3]

The practical lesson is to recognise failure early. Continuing observation without explaining persistent pleural blood, poor lung expansion or ongoing physiological compromise risks converting an acute problem into a more difficult one. The handover must state who will review the drain, what change should trigger a call and which service will provide definitive treatment.

Rib fractures and the loss of respiratory function

A rib fracture becomes clinically important through its effect on breathing, associated injury and the patient's reserve. Counting fractures is useful, but it does not describe the whole problem. We need to know whether the patient can take a useful breath, clear secretions and move without intolerable pain. Those observations help determine the level of care and whether treatment is working.

A radiological flail segment comprises at least three consecutive ribs fractured in at least two places. Clinical flail chest describes paradoxical movement during respiration. The anatomical pattern and the observed movement are related but are not interchangeable. Pain, chest wall instability and lung injury can contribute in different proportions to respiratory failure. [4]

Analgesia as part of respiratory treatment

Pain relief should enable deep breathing, coughing, sleep and mobilisation. A low pain score at rest is an incomplete measure if the patient still cannot cough. Use a multimodal regimen suited to renal function, bleeding risk, other injuries and vulnerability to sedation. Titrate opioids carefully and reassess respiratory effort and alertness rather than simply escalating the prescription.

Early anaesthetic or acute-pain input allows consideration of regional analgesia when systemic treatment is insufficient. The choice between epidural, paravertebral and fascial-plane approaches depends on anatomy, expertise, haemodynamics, anticoagulation and other contraindications. The EAST blunt-thoracic-trauma guideline conditionally supports multimodal analgesia and epidural analgesia, while acknowledging very low-quality evidence. [5]

Older adults need particular attention to frailty, baseline lung disease, confusion and the ability to cooperate with respiratory care. The joint EAST/CWIS review supports incentive spirometry and selected non-invasive respiratory support, but does not establish routine intensive-care admission or a single superior regional analgesic technique for every older patient with multiple rib fractures. Assessment must remain individual. [6]

When to consider rib fixation

Surgical stabilisation should be considered for flail chest and selected non-flail injuries, including multiple severely displaced fractures, deformity or instability that compromises function, and persistent respiratory impairment despite appropriate treatment. The 2024 WSES/CWIS position paper supports early fixation, generally within 48 to 72 hours where feasible. Haemodynamic instability takes priority over fixation; lung contusion, age and associated brain injury require individual assessment rather than automatic exclusion. [4]

The decision should identify a specific benefit we expect from restoring chest wall mechanics. It should also acknowledge what fixation cannot correct, including substantial parenchymal injury. Explain the alternatives and the risks of infection, persistent pain, implant symptoms and further intervention. The patient's overall recovery is the outcome that matters.

Planning chest wall reconstruction

Rib fixation requires the same attention to biology and soft tissues as fracture surgery elsewhere, with the additional need to protect structures immediately beneath the bone. Preoperative imaging should establish which fractures account for instability and whether other intrathoracic injuries require treatment during the same episode. The operative plan should be agreed between the clinicians responsible for the chest wall, lung, anaesthesia and postoperative care.

Taylor, French and Fowler describe posterolateral, muscle-sparing, axillary and anterior pectoralis-lifting approaches. Their work shows how fracture location and scapular position affect access. The long thoracic nerve, serratus anterior and surrounding muscle attachments deserve deliberate protection. Their 21-patient series is useful technical evidence; it does not prove that one approach is superior for all patients. [7]

Marasco and Saxena emphasise mapping fractures with CT, choosing positioning according to their distribution, preserving periosteal and intercostal attachments, and adapting the construct to rib curvature. These principles remain useful. Some selection exclusions and device-specific statements in this 2015 article reflect practice at that time and should be interpreted alongside contemporary guidance. In particular, severe associated injuries call for multidisciplinary assessment rather than uncritical application of historical exclusions. [8]

For the orthopaedic surgeon, this is a familiar responsibility in a less familiar region: restore useful mechanics while limiting the additional injury created by exposure. A technically neat plate does not justify a plan that compromises the lung, neurovascular structures or the patient's ability to recover. The anticipated duration of surgery, positioning and postoperative ventilation must be part of the decision.

Pulmonary contusion and respiratory support

Pulmonary contusion involves haemorrhage and oedema within injured lung tissue. Gas exchange may worsen after the initial assessment, so the first apparently reassuring examination does not settle the subsequent course. Treatment is predominantly supportive: appropriate oxygenation, effective analgesia, secretion clearance and respiratory support when necessary. Intubation is driven by failure of oxygenation, ventilation or airway protection and by the wider injury pattern. A flail segment alone is not an automatic indication. [9]

Once immediate resuscitation needs are met, avoid unnecessary fluid loading while maintaining organ perfusion. Non-invasive ventilation is suitable only for selected cooperative patients with close monitoring and rapid access to intubation if it fails. Invasive ventilation should limit additional lung injury. Corticosteroids are not a treatment for pulmonary contusion itself. [9]

Continuing respiratory decline requires a fresh explanation. Review the airway, pleural space, analgesia, ventilation and other injuries before assuming that contusion accounts for every change. This habit prevents a known diagnosis from concealing a new problem.

Cardiac injury and obstructed circulation

Thoracic shock may arise from blood loss, impaired cardiac filling, myocardial injury or a combination. The finding of one cause should not close the assessment. A patient can have pleural bleeding and tamponade together, or a significant cardiac injury while external signs remain modest.

When blunt cardiac injury is suspected, obtain an ECG and troponin. EAST recommends monitored care for new ECG abnormalities or elevated troponin I, and echocardiography for haemodynamic instability or a persistent new arrhythmia. Normal ECG and troponin I support exclusion of clinically significant injury within this pathway, although the optimal timing of testing is not established. Use the local assay and repeat-testing protocol. An isolated sternal fracture does not, by itself, mandate cardiac monitoring when these tests are normal. [10]

Traumatic tamponade restricts filling as blood accumulates within the pericardium. Bedside ultrasound can support rapid recognition, but treatment decisions must also account for mechanism and physiology. Definitive care usually requires surgical access and control of the cardiac injury. Needle aspiration may provide only temporary relief and does not repair the bleeding source. [16]

Blunt thoracic aortic injury

High-energy deceleration should prompt consideration of aortic injury. Contrast-enhanced CT angiography defines the lesion in a patient who can undergo imaging safely. Early vascular involvement is essential because management depends on injury morphology, associated injuries and the risk of rupture. Blood-pressure management must also protect cerebral and other organ perfusion.

The 2026 Society for Vascular Surgery update recommends definitive nonoperative management for SVS Grade I and II injuries. Higher-grade injury may require thoracic endovascular repair, with timing determined by stability and competing priorities. Classification should be named explicitly because grading systems are not interchangeable. Nonoperative management remains active specialist care with an appropriate follow-up plan. [11]

Traumatic cardiac arrest and resuscitative thoracotomy

Traumatic arrest demands immediate correction of reversible causes, particularly haemorrhage, hypoxia, tension pneumothorax and tamponade. The 2025 UK guidance prioritises these treatments while continuing chest compressions unless they delay or prevent correction. Its algorithm includes bilateral thoracostomies when indicated and links invasive interventions to trained personnel and appropriate resources. [12]

Resuscitative thoracotomy is reserved for selected circumstances. EAST gives its strongest recommendation to pulseless patients with penetrating thoracic injury who retain signs of life. Selection after blunt injury is more restrictive, and the guideline conditionally recommends against the procedure in patients arriving without signs of life after blunt trauma. Mechanism, elapsed time, potentially reversible injury and team capability must all inform the decision. [13]

Injuries that require deliberate exclusion

Some chest injuries declare themselves through failure of apparently appropriate treatment. Persistent air leakage, failure of the lung to expand despite functioning drainage, or unexplained ventilation difficulty should raise concern about a major airway injury. Tracheal or bronchial disruption requires coordinated airway management and early specialist assessment; bronchoscopy provides direct evaluation. Repeated blind adjustments can compound the original injury. [16]

The diaphragm deserves particular attention after thoracoabdominal penetration or substantial blunt trauma. A small defect can be difficult to see and may later permit herniation. EAST conditionally favours laparoscopy over CT alone to exclude diaphragmatic injury in stable patients with left thoracoabdominal stab wounds and no peritonitis. This is a defined clinical situation, not a rule that every chest wound requires laparoscopy. Other patterns require an individual operative or imaging strategy. [14]

Oesophageal injury may initially be subtle. A suspicious penetrating trajectory, unexplained mediastinal findings, pleural contamination or evolving sepsis warrants urgent investigation. WSES recommends contrast CT with CT oesophagography in stable patients with suspected traumatic oesophageal injury, with endoscopy as an adjunct where required. Treatment must address contamination, nutrition and the defect itself; delay can make a repair substantially more difficult. [15]

The chest injury within the multiply injured patient

Thoracic injury influences the timing and burden of operations elsewhere. Before definitive limb or pelvic reconstruction, the team should review oxygen requirements, ventilatory support, haemodynamics, bleeding, temperature and the expected length and position of surgery. An improving patient and a deteriorating patient may have similar CT appearances but very different capacities to tolerate intervention.

There is no useful substitute for a shared plan. The orthopaedic surgeon needs to understand the respiratory problem; the anaesthetist needs to understand the proposed operation; and critical care needs to know what support is likely afterwards. The aim is to choose an operation that advances recovery without consuming reserve that the patient does not yet have.

This brings us back to the philosophy of early appropriate care. Stabilisation can reduce pain and facilitate nursing and mobilisation. It can also impose blood loss, operative time and physiological stress. We should make that balance explicit, reassess it as the patient changes and document the reasons for proceeding, staging or postponing surgery.

Reassessment rehabilitation and continuity

A successful emergency intervention creates the opportunity for the next stage of care. Review respiratory effort, oxygen requirement, cough, pain during movement, mobility and drain function. Re-examine the chest and shoulder girdle during the secondary and tertiary surveys. New symptoms, unexpected deterioration and disagreement between clinical findings and imaging all deserve attention.

Recovery should include a practical plan for analgesia, respiratory exercises, supported coughing and progressive activity suited to associated injuries. Ask about sleep, confidence, daily tasks and the effect of pain on participation. These conversations can reveal a poor recovery that would be missed by checking fracture union alone.

At discharge, the patient should understand the medication plan, expected review and who to contact for worsening breathlessness, fever, haemoptysis or increasing chest pain. Ongoing limitation needs reassessment for unresolved pleural disease, infection, persistent instability, symptomatic nonunion or another cause. We should avoid attributing continuing disability to a normal recovery without examining its explanation.

Applying the principles

Consider an illustrative patient with multiple displaced rib fractures, a pulmonary contusion and a femoral shaft fracture. Initial resuscitation restores circulation, but breathing remains shallow and coughing is ineffective. The immediate task is to establish whether pain, pleural pathology, lung injury or several factors account for the impairment. Effective analgesia and treatment of the pleural space may change the operative picture substantially.

If oxygenation and physiology improve, definitive fracture treatment may become reasonable after joint review. If respiratory support and circulatory requirements are increasing, a shorter stabilising procedure may better match the patient's reserve. Chest wall fixation should likewise be considered for a defined mechanical or functional problem. The presence of an implantable fracture is insufficient justification on its own.

The central lessons of thoracic trauma care

- Understand the structure and mechanics of the thorax before interpreting how injury has disrupted them.
- Recognise immediately reversible threats and let physiology determine whether treatment must precede imaging.
- Assess the effect of rib injury on breathing and function, and judge analgesia by what it enables the patient to do.
- Select reconstruction according to expected benefit, current evidence and the patient's capacity to tolerate surgery.
- Reassess after intervention and maintain a clear plan across every handover.

For me, thoughtful chest trauma care joins decisive treatment of immediate danger with sustained attention to recovery. Restoring air entry, circulation or chest wall stability is valuable because it helps the injured person regain useful breathing, movement and independence.

References

Sources checked on 13 October 2026. References 7 and 8 were consulted in the author's Google Drive collection. Earlier technical papers inform operative principles; current guidelines inform selection and management.

1. National Institute for Health and Care Excellence. Major trauma assessment and initial management. NG39. 2016. Recommendations on chest injury, decompression and imaging. [Read source](#)
2. Coccolini F, Cremonini C, Moore EE, et al. Thoracic trauma WSES-AAST guidelines. World Journal of Emergency Surgery. 2025;20:78. doi:10.1186/s13017-025-00651-1. [Read source](#)
3. Patel NJ, Dultz L, Ladhani HA, et al. Management of simple and retained hemothorax. An EAST practice management guideline. American Journal of Surgery. 2021;221:873-884. doi:10.1016/j.amjsurg.2020.11.032. [Read source](#)
4. Sermonesi G, Bertelli R, Pieracci FM, et al. Surgical stabilization of rib fractures. The WSES and CWIS position paper. World Journal of Emergency Surgery. 2024;19:33. doi:10.1186/s13017-024-00559-2. [Read source](#)
5. Galvagno SM Jr, Smith CE, Varon AJ, et al. Pain management for blunt thoracic trauma. EAST and Trauma Anesthesiology Society guideline. Journal of Trauma and Acute Care Surgery. 2016;81:936-951. [Read source](#)
6. EAST and Chest Wall Injury Society. Non-surgical management and analgesia strategies for older adults with multiple rib fractures. Joint practice management guideline. EAST online guideline 2022; journal publication 2023. [Read source](#)
7. Taylor BC, French BG, Fowler TT. Surgical approaches for rib fracture fixation. Journal of Orthopaedic Trauma. 2013;27:e168-e173. Consulted from the author's Google Drive reference collection. [Read source](#)
8. Marasco S, Saxena P. Surgical rib fixation technical aspects. Injury. 2015;46:929-932. doi:10.1016/j.injury.2014.12.021. Consulted from the author's Google Drive reference collection. [Read source](#)

References continued

9. Simon B, Ebert J, Bokhari F, et al. Management of pulmonary contusion and flail chest. EAST practice management guideline. Journal of Trauma and Acute Care Surgery. 2012;73:S351-S361. [Read source](#)
10. Clancy K, Velopulos C, Bilaniuk JW, et al. Screening for blunt cardiac injury. EAST practice management guideline. Journal of Trauma and Acute Care Surgery. 2012;73:S301-S306. [Read source](#)
11. DuBose JJ, et al. The Society for Vascular Surgery clinical practice guideline on the management of blunt thoracic aortic injury. Focused update. Journal of Vascular Surgery. 2026;83:1281-1290.e8. doi:10.1016/j.jvs.2026.02.013. See also the official SVS release of 24 March 2026. [Read source](#)
12. Resuscitation Council UK. Special circumstances guidelines and traumatic cardiac arrest algorithm. Resuscitation Guidelines 2025. [Read source](#)
13. Seamon MJ, Haut ER, Van Arendonk K, et al. An evidence-based approach to patient selection for emergency department thoracotomy. EAST practice management guideline. 2015. [Read source](#)
14. EAST. Diaphragmatic injury evaluation and management. Practice management guideline. 2018. [Read source](#)
15. Chirica M, Kelly MD, Siboni S, et al. Esophageal emergencies. WSES guidelines. World Journal of Emergency Surgery. 2019;14:26. doi:10.1186/s13017-019-0245-2. [Read source](#)
16. Joint Trauma System. Wartime thoracic injury. Clinical Practice Guideline 74. 26 December 2018. Used for general recognition of airway and cardiac injury; operational recommendations remain setting-specific. [Read source](#)

CHAPTER FOUR

Abdominal Trauma

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

Abdominal trauma demands early judgement because the most dangerous injury may be concealed. A patient can lose blood into the abdomen or retroperitoneum without an obvious external wound. Bowel damage may produce little initial tenderness, yet later cause peritonitis and sepsis. We must therefore bring the mechanism of injury, repeated examination, physiological response and imaging together from the beginning.

My approach is to regard the first operation as part of resuscitation. Its extent should match what the patient can tolerate. Sometimes definitive repair is appropriate at the first intervention. Sometimes the useful operation is shorter: control bleeding, limit contamination, and create the conditions for a safer return to theatre. The aim is to preserve life while protecting the possibility of recovery.

This chapter addresses adult abdominal trauma within the wider care of the multiply injured patient. It explains the anatomical basis of injury, the choice between investigation and immediate intervention, and the principles of definitive and damage-control surgery. Paediatric trauma and trauma in pregnancy require additional specialist pathways.

Anatomy that explains the injury

The abdomen extends from the diaphragm to the pelvis and has a largely muscular anterior and lateral wall. Unlike the thorax, it lacks a complete surrounding bony cage. Its compliance permits deformation during impact; apparently modest surface injury can accompany substantial damage underneath.

The lateral abdominal muscles are the external oblique, internal oblique and transversus abdominis. The paired rectus abdominis muscles lie anteriorly within their sheaths. Deep to the muscular wall lie the transversalis fascia, extraperitoneal tissue and parietal peritoneum. A penetrating wound crosses the layers that lie along its particular trajectory; it does not necessarily traverse every abdominal muscle in sequence. [14]

The peritoneum is a thin serous membrane. Its parietal layer lines the cavity and its visceral layer covers many organs. The intervening potential space normally contains a small amount of lubricating fluid. Mesenteries and peritoneal folds support organs and transmit vessels, nerves and lymphatics. These attachments matter in trauma because relatively mobile bowel can move differently from fixed structures during sudden deceleration. [15]

The gastrointestinal tract passes from the short abdominal oesophagus into the stomach, duodenum, jejunum and ileum. The terminal ileum joins the caecum at the ileocaecal junction. The appendix arises from the caecum. The large bowel continues through the ascending, transverse, descending and sigmoid colon to the rectum and anal canal. The liver, gallbladder, biliary tree and pancreas contribute to digestion; the spleen has haematological and immune functions. The ampulla of Vater is the junction of the bile and

pancreatic ducts opening into the second part of the duodenum, rather than a separate organ.

The ligament of Treitz supports the duodenojejunal junction. It does not surround the duodenum. Fixed points, mesenteric attachments and vascular pedicles help explain why deceleration can cause tearing, vascular disruption or loss of bowel perfusion.

Table 4.1 Abdominal and pelvic compartments

Compartment	Examples and anatomical relationships	Why it matters
Intraperitoneal	Stomach, spleen, most liver surface, jejunum, ileum, transverse and sigmoid colon.	Bleeding or enteric leakage can enter the peritoneal space.
Retroperitoneal	Kidneys, ureters, aorta and inferior vena cava; most duodenum and pancreas; ascending and descending colon.	Haemorrhage or leakage may be concealed from FAST and early examination.
Pelvic and extraperitoneal	Empty bladder is mainly extraperitoneal. Rectal peritoneal coverage varies by level.	Urinary, rectal, vascular and pelvic-ring injuries may coexist.
Diaphragm	Separates the thoracic and abdominal cavities; lower chest wounds may cross it.	Assess both chest and abdomen when the trajectory or mechanism warrants it.

This compartmental view is clinically useful. Intraperitoneal blood may be detected by focused ultrasound, while important retroperitoneal injury can remain concealed. Urine, bile, intestinal contents and pancreatic secretions create different patterns of inflammation and contamination. Finding one injured organ does not complete the search.

Mechanism and the three dimensional injury

Blunt trauma can compress an organ against the vertebral column, stretch a mesentery or tear a vascular attachment. Road collisions, falls, crush injuries and direct blows produce different combinations of these forces. A seat-belt mark is a clue to the route of loading through the abdominal wall, particularly when bowel, mesenteric or spinal injury is possible.

We should reconstruct the event as far as the available information permits. What struck the patient? Where was the impact? How was the body positioned? Was the torso restrained, flexed or rotated? Was there a fall, sudden deceleration or repeated impact? Body habitus, contact area and the structures compressed between the object and the spine influence the injury. The mechanism generates a working hypothesis; it cannot establish or exclude the diagnosis by itself.

Knives, machetes, fragments and bullets can penetrate the abdominal wall. The external wound gives incomplete information about depth and internal trajectory. Ballistic injury also depends on projectile behaviour and energy transfer, so wound diameter alone cannot predict tissue destruction. Lower chest, flank, back, pelvic and perineal wounds may involve abdominal structures. A retained object should remain in place until removal can be controlled by the treating surgical team.

Abdominal injury in the primary survey

Abdominal assessment begins during the primary survey. It is particularly important under C because concealed haemorrhage can be fatal, but its consequences cross the whole assessment. Airway protection may be lost as shock or associated brain injury worsens. Vomiting creates an aspiration risk. Pain can restrict ventilation, while diaphragmatic injury, herniation or severe abdominal distension can impair breathing directly. These problems must be treated alongside the abdominal injury.

At C, assess perfusion and search for bleeding in all plausible locations. An injured abdomen may coexist with chest, pelvic, long-bone and external blood loss. A low blood pressure should not be assigned to a single compartment without considering the others. Conversely, a normal pressure at one moment does not settle the question of ongoing haemorrhage.

At D, record consciousness and recognise the limitations it creates for abdominal examination. Sedation, intoxication, neurological injury and distracting pain can make a reassuring examination unreliable. At E, expose enough of the patient to inspect the abdomen, flanks, back and perineum as appropriate, while maintaining dignity, spinal precautions where indicated and active protection from heat loss. Bruising, abrasions, penetrating wounds, distension and tenderness should be documented. Their absence does not exclude internal injury.

Table 4.2 Findings that need interpretation over time

Finding	Clinical implication
Bruising or a seat-belt mark	Raises suspicion of underlying injury; absence of a mark is not reassuring by itself.
Tenderness or involuntary guarding	May indicate visceral injury or peritonitis; early findings may be limited.
Reduced consciousness or distracting injury	Makes the abdominal examination less reliable.
Distension or worsening ventilation	Consider bleeding, ileus, associated thoracic injury and pathological abdominal pressure.
Deterioration after initial improvement	Reassess the source of shock and the need for intervention immediately.

Repeated examination has value only when changes reach someone who can act on them. The trauma leader should know who will review the abdomen again, what remains uncertain and what finding will change the plan. A handover that says only “abdomen soft” loses the mechanism, the reliability of the examination and the patient's direction of change.

Resuscitation and the choice of investigation

Resuscitation and source control proceed together. Activate the major haemorrhage pathway when indicated, provide blood products according to the local protocol, prevent hypothermia and monitor coagulation and ionised calcium. Follow perfusion and metabolic trends, including lactate or base deficit. A near-normal initial haemoglobin does not exclude substantial acute blood loss. Tranexamic acid is indicated as early as possible, within three

hours of injury, when significant bleeding is present or anticipated, using the applicable trauma protocol. [1]

The question before moving to CT is whether the patient can safely tolerate the journey, scan and time before treatment. NICE advises restricting imaging to what is needed to direct intervention in haemodynamically unstable patients who are not responding to resuscitation. Immediate CT is appropriate to consider when haemodynamics are normal or the patient is responding sufficiently. An indicated CT must not be delayed by performing FAST first. [2]

Focused assessment with sonography for trauma, or FAST, can rapidly identify free fluid and support an urgent decision. It does not reliably exclude intraperitoneal or retroperitoneal bleeding, and it is not a rule-out test for bowel injury. CT with intravenous contrast gives a much fuller account of injury in patients who can undergo it safely. CT may be part of the initial assessment; it is not reserved automatically for the secondary survey. [2,3]

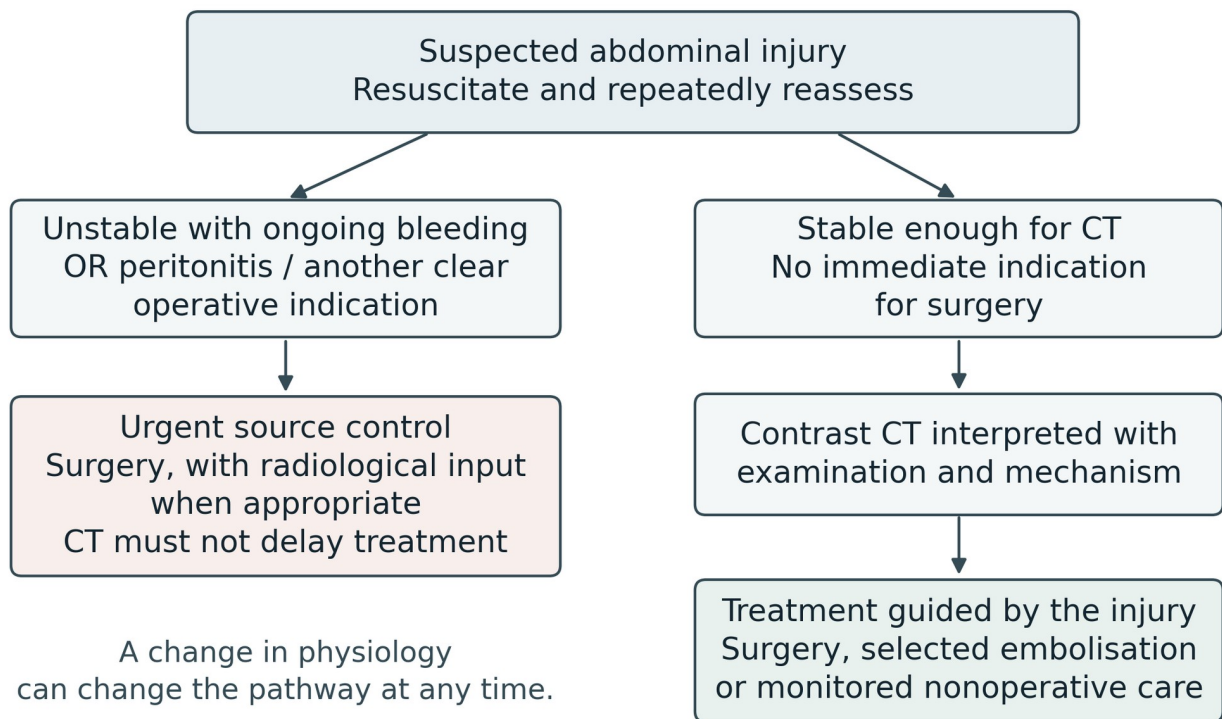


Figure 4.1 Investigation follows physiological safety. Original educational synthesis of references 1 to 4 and 9; individual findings and local resources determine the intervention.

A transient improvement requires particular caution. Ask what intervention produced it, whether it is sustained and what support is still required. Continued transfusion dependence or recurrent deterioration can make a patient unsafe for a diagnostic detour. The responsible surgeon and anaesthetist must be ready to revise the destination as physiology changes.

The language of a golden hour should communicate urgency, not create a timetable that permits waiting. Neither an arbitrary first hour nor a second hour defines when laparotomy

becomes necessary. The timing follows the threat and the fastest appropriate route to control it.

Solid organ injury and active nonoperative care

Many liver injuries can be managed without laparotomy when haemodynamics are stable and no other injury requires surgery. Contrast CT defines the injury, while monitoring and repeated assessment detect failure of the initial plan. Active arterial bleeding may be treated by angiography and embolisation in an appropriate patient. Anatomical grade contributes to risk assessment but does not, on its own, determine the operation. Persistent instability requires a different response. [4]

Splenic care similarly combines physiological assessment, injury characteristics and available expertise. Embolisation can help preserve the spleen while controlling arterial bleeding. Selected high-grade injuries warrant consideration of angiography even without a CT blush. Follow-up imaging is risk based; the World Society of Emergency Surgery (WSES) consensus supports contrast-enhanced ultrasound or CT at 48 to 72 hours for adults with American Association for the Surgery of Trauma (AAST) grade III or higher injuries managed nonoperatively. This recommendation should not be applied indiscriminately to children. [5]

Nonoperative care is an active treatment plan. It needs an appropriate monitoring environment, clear escalation criteria and timely access to intervention. The patient should not simply be described as “for observation” without specifying the concern and the route to rescue. Organ preservation is valuable when it is compatible with haemorrhage control and the patient's overall condition.

Bowel mesentery pancreas and biliary injury

Bowel injury can involve direct perforation or loss of blood supply after mesenteric damage. Peritoneal signs may develop late. On CT, a definite bowel-wall defect or convincing extraluminal enteric contrast supports exploration; less specific findings need interpretation with the mechanism and clinical course. Equivocal findings warrant serial assessment and, in selected stable patients, repeat CT, often at about six hours under WSES guidance. Deterioration or peritonitis should prompt operative reassessment rather than waiting for a scheduled scan. [3]

The duodenum and most of the pancreas lie deep in the retroperitoneum, where injury may initially be subtle. Persistent pain, an unexplained clinical course or suspicious imaging requires specialist review. In a stable patient with continuing suspicion, repeat CT within 12 to 24 hours may be appropriate. Pancreatic duct integrity is an important determinant of treatment; MRCP or ERCP can contribute in selected circumstances. These investigations must fit the patient's stability and the available expertise. [6]

Biliary injury can produce leakage even when haemorrhage is controlled. Gallbladder, bile duct, duodenal and pancreatic injuries should therefore be considered in relation to one another. Management may combine surgery, drainage, endoscopy or radiological intervention. A normal early examination should not end investigation when the anatomical mechanism and subsequent progress remain concerning. [6]

Pelvic retroperitoneal and urinary injury

The pelvis and abdomen must be considered together in a patient with shock. Blood can be lost into both spaces, and identifying a pelvic fracture does not exclude a bleeding abdominal organ. The operative and interventional radiology teams need a shared account of the likely sources and of the intervention that can control them most promptly.

Katsura and colleagues examined 317 patients with pelvic fracture and haemoperitoneum in the Japan Trauma Data Bank. They found no statistically significant adjusted mortality difference between laparotomy-first and angiography or embolisation-first groups. The retrospective design, different injury patterns and wide confidence interval prevent an inference of equivalence. The study supports careful interpretation of combined injuries; it does not justify delaying necessary laparotomy in a deteriorating patient. [7]

Renal and collecting-system injury can occur without haematuria. Appropriate contrast CT phases, including delayed images when indicated, help identify urinary leakage or ureteric injury. Suspected bladder rupture requires actively filled CT or conventional cystography; passive bladder filling during routine intravenous contrast CT is inadequate. Traumatic intraperitoneal bladder rupture generally requires repair, while uncomplicated extraperitoneal blunt rupture is often treated with drainage. [8]

Blood at the urethral meatus or a mechanism suggesting urethral disruption requires a deliberate urological plan before blind catheterisation. In men, retrograde urethrography and/or cystourethroscopy are used as appropriate. Genital and reproductive-organ injuries require examination and the relevant specialist input. Preserving privacy and explaining the examination remain part of trauma care whenever circumstances permit. [8]

Penetrating and thoracoabdominal wounds

Haemodynamic instability, peritonitis or another clear operative indication after penetrating abdominal injury requires urgent surgical treatment. Some stable, cooperative patients without peritonitis can undergo selective nonoperative management, provided experienced repeated examination and immediate access to surgery are available. Stab wounds and gunshot wounds require different risk assessment; a pathway suitable for one should not be transferred uncritically to the other. CT can help define trajectory and injured structures, but it does not replace clinical surveillance. [9]

The diaphragm is the important boundary between Chapters 3 and 4. A wound through the lower chest can injure abdominal organs, and an abdominal wound can extend into the thorax. Small penetrating diaphragm defects can be missed on CT. In selected stable patients, especially with left thoracoabdominal stab wounds, laparoscopy may be required to assess the diaphragm. EAST's recommendation favouring laparoscopy over CT in this specific setting is conditional and based on limited-quality evidence. [10]

Choosing the extent of the first operation

The decision for laparotomy should be made by the responsible trauma or emergency general surgeon with anaesthesia, radiology and other necessary specialists. Vascular, hepatobiliary, colorectal and urological expertise may be required. The team should be mobilised early, but the need for discussion must not postpone treatment of an immediately life-threatening injury.

Definitive repair at the first operation is appropriate when the patient can tolerate the required intervention. Damage-control surgery is appropriate when ongoing haemorrhage, shock, coagulopathy, hypothermia, acidosis or the anticipated operative burden makes prolonged reconstruction hazardous. The decision should precede physiological collapse. Waiting until every adverse feature is present may lose the opportunity to abbreviate safely. [1]

The essential tasks are to control haemorrhage and contain contamination. Depending on the injury, this can involve packing, vascular control, limited repair or resection. Bowel continuity may need to be deferred. Document the remaining problems and the intended next operation before leaving theatre. The resuscitation team must know what has been controlled, what remains uncertain and what deterioration would require an earlier return.

Give timely antimicrobial cover for penetrating abdominal injury and suspected bowel contamination according to local protocols. Antibiotics supplement source control; duration depends on whether treatment is prophylactic or addresses established infection. [13]

Definitive Surgical Trauma Care, or DSTC, provides a framework for surgical care of patients with multiple injuries. [16] An exploratory laparotomy is an investigation with therapeutic responsibilities: once an injury is found, the surgeon must choose an effective intervention whose burden the patient can tolerate. Avoiding unnecessary operative time is part of treatment.

Early total care and early appropriate care are most closely associated with the timing of definitive fracture fixation. The transferable principle is the same: match the surgical burden to physiological reserve. They should not be presented as alternative named abdominal operations. For the abdomen, the practical distinction is between definitive repair and an abbreviated damage-control strategy, with associated orthopaedic procedures coordinated accordingly. [12]

Decompression and the open abdomen

Decompression is not a routine objective for every abdominal injury. It becomes necessary when pathological intra-abdominal pressure compromises organ function and abdominal compartment syndrome is not relieved by appropriate nonsurgical measures. Increasing ventilatory difficulty, oliguria and circulatory deterioration in the right context should prompt assessment, including intra-abdominal pressure measurement where indicated. [11]

Temporary abdominal closure may be needed after damage-control surgery because resuscitation continues, contamination remains, bowel viability is uncertain, an anastomosis has been deferred or closure would create harmful pressure. An open abdomen carries substantial costs, including fluid and protein loss, fistula risk and difficulty achieving later closure. WSES recommends re-exploration within 24 to 48 hours, sooner when deterioration requires it, and definitive fascial closure as soon as the clinical conditions permit. [11]

Reassessment recovery and shared responsibility

A completed operation or reassuring scan marks a stage in care. Review the patient's trajectory after every major intervention. Unexplained pain, distension, falling haemoglobin, recurrent shock, fever, worsening organ function or failure to progress should trigger a renewed search for bleeding, missed injury or a treatment complication.

The next team needs a precise account of the injuries identified, the imaging reviewed, the procedures performed and the questions still open. After damage-control surgery, this includes retained packs, bowel left in discontinuity, temporary closure and the timing and purpose of re-exploration. After nonoperative treatment, it includes the monitoring plan and explicit escalation criteria.

Recovery also depends on nutrition, analgesia, respiratory care, mobilisation and prevention of complications as the patient's condition allows. Associated head, chest, pelvic and limb injuries can change the sequence. The trauma surgeon's role is to maintain a coherent plan across those specialties and to explain that plan to the patient and family when possible.

Applying the reasoning

The following teaching examples are hypothetical and are not cases from the author's practice.

A patient after a road collision remains poorly perfused despite resuscitation, with findings supporting major intra-abdominal bleeding. The immediate question is how to obtain haemorrhage control. Additional imaging is useful only if it changes that intervention without creating dangerous delay.

A stable patient with a seat-belt mark has an equivocal abdominal CT. The absence of dramatic initial findings does not close the assessment. A documented observation and review plan allows evolving bowel or mesenteric injury to become apparent while a route to prompt intervention remains available.

A patient arrives with both a severe pelvic injury and suspected abdominal bleeding. The team must avoid treating the most obvious radiograph as an explanation for the entire physiological disturbance. Surgical and radiological findings need to be interpreted together to identify the bleeding source or sources.

My guiding question is how much treatment will help this patient now, and what must be deferred until recovery makes it safer. In abdominal trauma, sound judgement means recognising concealed injury early, controlling urgent threats promptly and reassessing the consequences of every decision.

References

1. Rossaint R, et al. The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition. *Critical Care*. 2023. doi:10.1186/s13054-023-04327-7. [Read source](#)
2. National Institute for Health and Care Excellence. Major trauma: assessment and initial management. NG39. Recommendations on imaging, haemorrhage and damage-control surgery. [Read source](#)
3. Smyth L, et al. WSES guidelines on blunt and penetrating bowel injury: diagnosis, investigations, and treatment. *World Journal of Emergency Surgery*. 2022;17:13. doi:10.1186/s13017-022-00418-y. [Read source](#)
4. Coccolini F, et al. Liver trauma: WSES 2020 guidelines. *World Journal of Emergency Surgery*. 2020. doi:10.1186/s13017-020-00302-7. [Read source](#)
5. Podda M, et al. Follow-up strategies for patients with splenic trauma managed non-operatively: the 2022 World Society of Emergency Surgery consensus document. *World Journal of Emergency Surgery*. 2022. doi:10.1186/s13017-022-00457-5. [Read source](#)
6. Coccolini F, et al. Duodeno-pancreatic and extrahepatic biliary tree trauma: WSES-AAST guidelines. *World Journal of Emergency Surgery*. 2019. doi:10.1186/s13017-019-0278-6. [Read source](#)
7. Katsura M, et al. Comparison between laparotomy first versus angiographic embolization first in patients with pelvic fracture and hemoperitoneum: a nationwide observational study from the Japan Trauma Data Bank. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*. 2013;21:82. doi:10.1186/1757-7241-21-82. [Read source](#)
8. European Association of Urology. EAU Guidelines on Urological Trauma. 2026 edition. Urogenital trauma guidelines. [Read source](#)
9. Eastern Association for the Surgery of Trauma. Penetrating Abdominal Trauma, Selective Non-Operative Management of. Practice management guideline. 2010. [Read source](#)
10. Eastern Association for the Surgery of Trauma. Diaphragmatic Injury, Evaluation and Management of. Practice management guideline. 2018. [Read source](#)
11. Coccolini F, et al. The open abdomen in trauma and non-trauma patients: WSES guidelines. *World Journal of Emergency Surgery*. 2018. doi:10.1186/s13017-018-0167-4. [Read source](#)
12. Vallier HA, et al. Complications are reduced with a protocol to standardize timing of fixation based on response to resuscitation. *Journal of Orthopaedic Surgery and Research*. 2015. doi:10.1186/s13018-015-0298-1. [Read source](#)
13. Eastern Association for the Surgery of Trauma. Penetrating Abdominal Trauma, Prophylactic Antibiotic Use in. Practice management guideline. 2012. [Read source](#)
14. US National Library of Medicine. Abdominal Wall. Medical Subject Headings descriptor D034861. [Read source](#)
15. Cleveland Clinic. Peritoneum. Medically reviewed anatomical resource. Updated 27 April 2022. [Read source](#)
16. International Association for Trauma Surgery and Intensive Care. Definitive Surgical Trauma Care course introduction. [Read source](#)

Chapter 5: Pelvis

Pelvic injuries and management in major trauma

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

A disrupted pelvis should make us think beyond the fracture. We must ask how the force entered the body, which structures were injured along its path, whether the patient is bleeding, and what treatment the patient can tolerate now. At the same time, we must recognise that pelvic haemorrhage can itself be rapidly fatal. The early task is to control threats to life while preserving the conditions for later reconstruction.

My approach is to build a three-dimensional picture of the injury, then place that picture within the physiology of the whole patient. A classification gives us a shared language. The circulation, associated injuries, neurological findings and soft tissues determine what we must do next. This chapter concerns principally adult major trauma and follows care from resuscitation through stabilisation, definitive treatment and rehabilitation.

The pelvic ring as a structural outlet

I find it useful to compare the pelvic girdle with the shoulder girdle around the upper thorax. The iliac wings can be imagined as broad counterparts to the scapulae, the pubic symphysis as an anterior connecting point, and the sacrum as the central posterior link to the spine. This is a teaching analogy, not an anatomical equivalence. The sternoclavicular joints are paired joints, whereas the pubic symphysis is a midline fibrocartilaginous joint; the shoulder girdle is designed for mobility, while the pelvis transfers substantial load.

The bony pelvis comprises two innominate bones, each formed from the ilium, ischium and pubis, connected posteriorly to the sacrum at the sacroiliac joints and anteriorly at the symphysis. The sacroiliac ligaments, sacrotuberous and sacrospinous ligaments, and pelvic floor contribute to stability. The pelvic inlet and outlet are different anatomical apertures. The pelvis is therefore better understood as a load-bearing ring surrounding the lower trunk than as a single bone or a direct replica of the thoracic inlet.

Its surrounding muscles can conceal deformity and substantial blood loss. Inside and around the ring lie the bladder, urethra, rectum, reproductive organs, major vessels, venous plexuses and lumbosacral neural structures. A ring disruption can damage several of these simultaneously. An anterior fracture is a reason to inspect the posterior ring carefully; a modest anterior appearance does not establish that the injury is minor.

Clinical scope: this chapter explains principles and decisions for healthcare professionals. Invasive procedures require trained teams, appropriate imaging and the current local major-trauma pathway.

The fracture and the whole injured patient

High-energy pelvic disruption records a substantial transfer of force. That force does not stop at the fracture line. Head, chest, abdominal, spinal and limb injuries may determine survival, and age, frailty and comorbidity influence the patient's capacity to recover. We should resist diagnostic anchoring: finding a pelvic fracture does not complete the search for the source of shock.

What our mortality research showed

In our study, The pelvic fracture - Indicator of injury severity or lethal fracture?, Holtenius, Bakhshayesh and Enocson examined a Swedish trauma cohort. The increased crude mortality association did not persist as an increased risk after adjustment for factors including injury severity, shock, consciousness, age and comorbidity. The study supported viewing pelvic fracture within the wider injury burden. It was observational and does not establish that a pelvic fracture is protective or that pelvic bleeding cannot cause death. [1]

In a separate series of 385 adults with high-energy pelvic and/or acetabular injuries, Bakhshayesh, Weidenhielm and Enocson reported 30 deaths within 30 days and 36 within one year. Traumatic brain injury was a prominent cause of death, and reduced consciousness and advanced age were important predictors. Four deaths were attributed to pelvic bleeding. The cohort excluded patients dead before hospital arrival, which limits conclusions about the earliest lethal injuries. [2]

The evidence also varies between populations. A national Swedish study published in September 2026 included 11,624 trauma patients aged 60 years or older. Pelvic or acetabular injury remained associated with 30-day mortality after adjustment for sex, ASA class, NISS and head injury: adjusted odds ratio 1.28, with a 95% confidence interval of 1.03-1.57. Its population and statistical model differed from our earlier work. These findings reinforce the need for careful risk assessment in older patients and caution against a universal causal conclusion from any single cohort. [3]

Where bleeding occurs

Blood may escape from disrupted pelvic veins, cancellous fracture surfaces, arterial branches or major vessels. Venous and bony bleeding may respond to mechanical stabilisation and packing; arterial bleeding may need embolisation or vascular surgery. Mixed bleeding is common. Retroperitoneal haemorrhage can be extensive without obvious external blood loss, and a negative abdominal ultrasound does not exclude it. [4,7,18]

My conclusion is practical: treat the pelvis promptly when it is contributing to shock, while continuing to assess the entire patient. Neither the dramatic radiograph nor the apparently modest fracture should be allowed to dictate the diagnosis on its own.

Mechanism and classification

Young-Burgess describes the dominant injury mechanism and resulting pattern. Anteroposterior compression commonly produces external rotation and opening of the ring; lateral compression produces internal rotation or impaction; vertical shear produces vertical translation with major posterior disruption. Actual trauma may combine these forces. The classification is an aid to understanding, not a reconstruction of every movement during the accident. [23]

Pattern	Principal features	Clinical interpretation
APC I	Limited anterior opening with posterior restraint preserved.	Often mechanically stable, but apparent widening alone cannot prove ligament integrity.
APC II	Anterior opening and disruption of anterior sacroiliac structures; posterior restraint persists.	Rotational instability. Assess bleeding and the entire posterior injury.
APC III	Complete posterior sacroiliac disruption with anterior injury.	Rotational and vertical instability; potentially major haemorrhage.
LC I	Pubic rami injury with sacral compression or fracture.	A spectrum: incomplete impaction may be stable; complete or displaced sacral injuries can be unstable.
LC II	Lateral compression with posterior iliac or sacroiliac injury, often a crescent fracture.	Posterior involvement needs specialist assessment of mechanical stability.
LC III	Compression on one side with opening of the opposite hemipelvis.	A windswept pattern with substantial instability; not a benign compression injury.
Vertical shear	Vertical displacement through the anterior and posterior ring.	Assess neural injury, sacral disruption and cranial translation; traction may be appropriate.
Combined	Elements of more than one mechanism.	Describe the actual displacement and posterior lesion rather than forcing a single label.

Table 5.1. A simplified clinical guide to Young-Burgess patterns. LC I is heterogeneous; apparently small displacement does not reliably establish stability. Specialist review may require further assessment. Cadaveric binder-stress research illustrates this heterogeneity but does not establish a routine bedside test. [21,23]

Traditional descriptions often use 2.5 cm of symphyseal widening to help distinguish APC I from APC II. This is a teaching guide, not a universal biological threshold. Binder reduction, recoil after injury and individual anatomy can conceal ligament disruption. Decisions must use the whole injury, not one measurement.

Stability physiology and communication

Tile and the posterior pelvic ring

Tile emphasises mechanical stability. Type A injuries are stable; type B injuries are rotationally unstable but retain vertical stability; type C injuries are rotationally and vertically unstable. The posterior ring is central to this assessment. Tile and Young-Burgess describe related aspects of the same injury, but are not perfectly interchangeable. Both can inform operative planning and multidisciplinary discussion; neither belongs exclusively to one specialty. [4,22]

Mechanical state	Haemodynamic state	Immediate implication
Stable or uncertain	Stable after assessment	Complete imaging and associated-injury assessment; define mobilisation and observation.
Unstable	Stable after resuscitation	Protect alignment and organise timely specialist reconstruction.
Any pattern	Persistent or recurrent shock	Resuscitate and identify/control bleeding urgently; anatomy alone cannot justify waiting.

Table 5.2. Mechanical instability means failure of the ring to resist displacement. Haemodynamic instability means inadequate circulation or continuing support needed to maintain it. These are separate questions.

The classification should organise care

An APC pattern alerts us to opening of the ring and possible loss of haemostatic support. An LC pattern prompts scrutiny of sacral impaction, posterior completeness and internal rotation. Vertical shear draws attention to displacement, nerve injury and possible lumbopelvic disruption. These associations help us prepare; they do not rank patients safely without physiological information.

In particular, lateral compression does not mean that there is time to wait. A patient with an LC injury may have arterial bleeding, an open wound, abdominal injury or deteriorating circulation. Conversely, a patient with a markedly displaced injury may become physiologically stable after effective resuscitation. The team must reassess the person, rather than repeatedly reciting the original category. [18,21]

A useful referral states the mechanism, current and changing physiology, blood-product requirement, binder position and application time, suspected bleeding source, actual posterior lesion, open wounds, neurological findings and associated injuries. It should also state the unresolved decision: immediate haemorrhage control, temporary stabilisation, urological intervention or definitive reconstruction.

Specialist transfer reflects the technical demands of pelvic and acetabular surgery and the need for coordinated services. Expertise, imaging, interventional radiology, critical care and rehabilitation must be available together. Referral pathways should make this collaboration timely and predictable. Patients with continuing haemodynamic instability who present elsewhere need immediate coordinated transfer to a capable major trauma centre, with resuscitation and urgent haemorrhage-control planning continuing. [5]

Initial assessment and resuscitation

Pelvic management sits within the repeated major-trauma primary survey. Control catastrophic external bleeding, secure oxygenation and ventilation, and assess circulation while protecting the spine where indicated. A pelvic intervention must not distract the team from a threatened airway, tension pneumothorax, intrathoracic bleeding or abdominal catastrophe.

Recognise shock before a single number reassures

Follow blood pressure and pulse trends alongside skin perfusion, mental state, lactate, base deficit, temperature and continuing transfusion requirement. An initial haemoglobin value may underestimate acute blood loss. Older patients and those taking rate-limiting medication may lack an expected tachycardia. A transient improvement after blood does not establish lasting haemostasis.

Activate the major haemorrhage protocol when indicated. Use warmed blood components, minimise avoidable crystalloid loading, and move from initial protocol-based replacement to treatment guided by coagulation tests or viscoelastic testing. Monitor and correct hypothermia, low ionised calcium and fibrinogen deficiency. Give tranexamic acid promptly for active or suspected significant bleeding, within three hours of injury under the trauma protocol. Resuscitation targets must account for associated brain injury, in which hypotension is particularly harmful. These measures accompany, rather than replace, control of the bleeding source. [7,8] Identify anticoagulant use and reverse clinically significant anticoagulation when indicated by the bleeding protocol. [7]

Examine without repeatedly disturbing the injury

Inspect the abdomen, groins, perineum and visible buttocks for wounds, bruising, swelling and degloving. Note limb position and length, examine distal perfusion, and document motor and sensory function when feasible. Avoid repeated pelvic springing or compression testing. Minimise unnecessary transfers and rolling; airway protection and other immediately necessary interventions still take priority. [5,6]

The first examination may be incomplete because of shock, unconsciousness, pain or sedation. Record those limitations explicitly. A normal limb pulse does not exclude an internal pelvic vascular injury, and an unreliable neurological examination must be repeated after resuscitation. Examine again after any reduction, traction or fixation.

Bring the necessary teams in early

The trauma leader should coordinate anaesthesia, emergency medicine, pelvic surgery, general or vascular surgery, interventional radiology and critical care. Urology, colorectal surgery, gynaecology, plastic surgery and spinal surgery join according to the injury. Calls for help should begin while resuscitation continues. Waiting for a complete classification before arranging expertise can lose the opportunity for timely haemorrhage control.

Analgesia, warmth, dignity and explanation are part of this early care. An awake patient may be frightened by the number of people and procedures. A named clinician should explain the immediate plan whenever the situation allows.

Imaging and the decision to intervene

The central imaging question is whether the patient can safely undergo CT or needs immediate intervention. This is a decision about physiology, response to resuscitation, scanner access and the available team. A full diagnostic sequence must not postpone haemorrhage control in a patient who is deteriorating.

The stable patient or sustained responder

Contrast-enhanced CT defines the pelvic ring, retroperitoneal haematoma, arterial extravasation and associated injuries. In adult blunt major trauma with suspected multiple injuries, this usually forms part of whole-body trauma imaging. Multiplanar images are essential for sacral fractures and posterior displacement; three-dimensional reconstructions can help spatial understanding but do not replace careful review of the source images. [6,7]

Look systematically at the sacrum, sacroiliac joints, iliac wings, anterior ring, symphysis and acetabula. Then inspect the soft tissues, bladder region, vessels and adjacent organs. A useful three-dimensional mental image includes rotation and vertical translation, the position of each femoral head, and the continuity between spine and pelvis. This makes the chosen stabilisation method intelligible.

Persistent instability or nonresponse

Use only the immediate imaging needed to direct urgent treatment. A portable pelvic radiograph can identify gross disruption when CT is unsafe. Bedside ultrasound can reveal intraperitoneal fluid, but a negative FAST cannot exclude abdominal or retroperitoneal haemorrhage. Continue to search for concurrent chest, abdominal, limb and external bleeding. The patient may have more than one source. [7,18]

An arterial contrast blush, ongoing transfusion need or recurrent shock should prompt urgent discussion of embolisation and/or operative control. Absence of a blush does not rule out continuing haemorrhage. A CT finding is one part of the decision, alongside the patient's trajectory and the speed with which treatment can actually be delivered. [18]

A binder can conceal displacement

A correctly applied binder may reduce an unstable injury so effectively that CT shows little separation. Do not remove it simply to obtain a more dramatic radiograph during shock. Once resuscitation permits, the pelvic team should plan controlled release and reassessment; BOAST recommends a post-binder pelvic radiograph in polytrauma, even after an apparently negative CT. [5]

Explain this issue at handover. A report saying that the pelvis appears aligned while bound is different from a conclusion that the unbound ring is mechanically stable. The removal plan, responsible team and subsequent imaging should be explicit.

The binder and temporary mechanical support

Apply the binder to the greater trochanters

For suspected active pelvic bleeding after blunt high-energy trauma, apply a purpose-made pelvic binder promptly. Centre it over the greater trochanters, not the waist or iliac crests, and follow the device instructions. Minimise movement during application, record the time and reassess circulation. The device acts through the proximal femora to support the pelvic ring. [6,9]

In an externally rotated injury, reduction can bring separated surfaces closer together and limit movement that disrupts clot. The familiar idea of reducing pelvic volume is useful but incomplete: the retroperitoneum is not a sealed container, and stabilisation matters as well as cavity size. A binder does not reliably control every arterial or major vascular injury. [10]

Our three-dimensional study of 73 applied binders found correct placement and alignment by the study criteria in 43 patients, or 59%. This was a quality-of-application study; it did not demonstrate a significant mortality difference between correctly and incorrectly applied devices. Its practical message is that simply documenting a binder as present is insufficient. We must check where it lies and how it supports the patient. [9]

Position the legs thoughtfully

Gentle adduction and internal rotation may assist closure of an externally rotated pelvis when associated hip, femoral, knee and other limb injuries permit. Abduction is not a generic manoeuvre for closing the ring. Do not force the legs together, impose internal rotation on an injured hip, or prescribe the same knee position for every patient. Padded support may maintain a selected position, but tight circumferential bandaging around knees and ankles is not a substitute for a pelvic binder.

After imaging, consider whether further compression suits the actual displacement. An already internally rotated hemipelvis should not be compressed indiscriminately. Equally, an unconfirmed suspicion of LC injury should not delay indicated emergency pelvic stabilisation in shock. Device adjustment and release need coordinated clinical review. [4,10,21]

A temporary device needs an exit plan

Monitor pressure areas and skin, maintain necessary access, and decide whether another form of stabilisation is required. NICE recommends removal of all binders within 24 hours of application, with a pelvic-surgeon plan before removal in a mechanically unstable injury. This is an active planning requirement, not an instruction to abruptly release an unstable pelvis at a deadline. [6]

If bleeding continues, escalating haemorrhage control is more important than repeatedly tightening the device. If mechanical support remains necessary, arrange an appropriate alternative rather than allowing prolonged binder pressure to become the default.

Controlling pelvic haemorrhage

Stabilisation, packing and embolisation address different parts of the problem and may be used together. The choice and sequence depend on physiological urgency, likely bleeding source, abdominal indications and the time to a functioning theatre or angiography service. A written local pathway should make those decisions rapid.

Angiography and embolisation

Angiography can identify and treat bleeding arterial branches. Embolisation is not synonymous with coiling: the interventional radiologist chooses the agent and degree of selectivity according to the lesion and urgency. NICE recommends interventional radiology for active arterial pelvic bleeding when emergency laparotomy is not required. Persistent bleeding can require repeat angiography or additional surgery. [6,18]

A major iliac vascular injury with threatened limb perfusion may require vascular repair or another specialist reconstruction strategy. It should not be reduced to the assumption that every bleeding vessel can simply be embolised. Distal perfusion must be checked before and after intervention.

Preperitoneal or extraperitoneal pelvic packing

Packing supplies pressure around the bleeding pelvic surfaces, with a stabilised ring providing counterpressure. It is valuable when haemorrhage is severe, when rapid angiography is unavailable, or as part of coordinated damage-control surgery. Continuing arterial bleeding may still require embolisation. [8,11]

Direct pelvic packing generally accesses the extraperitoneal space through a low midline or Pfannenstiel approach while preserving the peritoneal sac. It is distinct from abdominal laparotomy. Associated abdominal injuries may require laparotomy in the same operation, but opening the abdomen is not an intrinsic requirement of pelvic packing. Routine opening of a contained blunt pelvic retroperitoneal haematoma from inside the abdomen can disrupt tamponade; exceptions require a defined surgical or vascular indication. [11]

Pack removal and abdominal closure

Record the packs and a planned return to theatre. Removal or revision follows resuscitation, correction of coagulopathy and the operative findings. AO describes a second look at 24-48 hours, whereas WSES describes revision at 48-72 hours; the team should specify the timing under its protocol and the patient's physiology. [4,11]

Pelvic packing does not automatically require an open abdomen. Where a separate damage-control laparotomy leaves an abdomen that cannot safely be closed, temporary abdominal closure may use an appropriate negative-pressure system with visceral protection and a planned re-exploration. That decision concerns the abdominal operation and physiological condition, not merely the presence of pelvic packs. [25]

Resuscitative endovascular balloon occlusion of the aorta is not routine pelvic-trauma care. Although proposed as a bridge in selected catastrophic haemorrhage, the UK-REBOA randomised trial found no survival benefit and raised concern about harm. Any exceptional use requires an established expert pathway and must not delay definitive haemostasis. [8,26]

External fixation traction and neural injury

Match mechanical support to the displacement

Method	Potential role	Important limit
Pelvic binder	Rapid circumferential support during resuscitation.	Temporary; cannot correct or hold every rotational or vertical deformity.
Anterior external fixator	Temporary stabilisation and support during haemorrhage control.	Does not alone reliably control a completely disrupted posterior ring.
Skeletal traction	Selected cranially displaced vertical-shear injuries awaiting fixation.	Needs specialist prescription, a suitable limb and repeat assessment.
Skin traction	Limited selected support where clinically appropriate.	Cannot deliver the forces required for many major vertical displacements.
Posterior emergency device	Selected posterior instability in experienced hands.	Pattern dependent; pin placement and compression can injure adjacent structures.

Table 5.3. Temporary methods are not interchangeable. The pelvic surgeon must select a construct that addresses the injured ring. [5,12]

External-fixator pin sites and frame position should accommodate later reconstruction, abdominal access, stomas and nursing. A pelvic C-clamp or other posterior emergency device is a specialist option, not a routine substitute for a binder. Safe use depends on the fracture and local expertise.

Traction is a prescription rather than a formula

Longitudinal skeletal traction can help selected cranially displaced vertical-shear injuries. A distal femoral or proximal tibial pin may be appropriate, but the choice depends on ipsilateral fractures, knee stability, wounds and the planned operation. Do not transmit traction through an injured joint or unsuitable limb without specialist assessment.

Ten per cent of body weight should not be taught as a universal pelvic-trauma prescription. Weight, direction and duration must be adjusted to the displacement, patient and radiographic response. AO describes forces that may exceed skin-traction tolerance. Traction can worsen an already distally displaced hemipelvis. Check alignment, skin, pin sites and neurovascular status repeatedly. [12]

Sacral and lumbopelvic injuries

Assess lower-limb power and sensation, perianal sensation and sacral function when clinically possible. New weakness, saddle sensory change or bowel and bladder dysfunction requires urgent specialist assessment. A reduced anal tone is a finding to document and investigate, not something that initial pelvic support guarantees to restore.

Vertical shear is not synonymous with spinopelvic dissociation. U-shaped or H-shaped sacral patterns can disconnect the spinal column from the pelvic ring and require expertise in both spinal and pelvic fixation. Neurological deficit and possible neural compression strengthen the need for urgent joint planning; decompression and fixation are individual decisions. [17]

Open injuries and urogenital assessment

A pelvic fracture can communicate with the exterior through a perineal, rectal or vaginal wound without an obvious wound over the iliac bones. Inspect the genitalia, urethral meatus, perineum, groins and buttocks with appropriate consent, analgesia and a chaperone. Intimate examination should be purposeful and coordinated, avoiding repeated examinations by several teams.

Rectum vagina and contaminated wounds

Assess for blood, tissue disruption and communication with the fracture. Rectal examination may identify blood or a palpable injury but cannot exclude rectal damage. Vaginal bleeding or suspected communication requires appropriate specialist examination. Normal sensation or anal function does not exclude a visceral injury. Urgent colorectal, urological and gynaecological input should follow the suspected anatomy.

Open pelvic injuries require early antibiotics suited to the contamination and local open-fracture policy, tetanus assessment, haemorrhage control and timely operative debridement. Anorectal injury or substantial perineal contamination may require faecal diversion. A stoma is selective, not automatic for every open fracture; its location and timing should accommodate later fixation and the patient's condition. Bladder leakage and bowel contamination require specific source control, not antibiotics alone. [5,14]

Suspected urethral injury and urinary drainage

Meatal blood, inability to void, perineal swelling, visible haematuria or difficulty passing a catheter should raise concern for urinary tract injury. Absence of these findings does not reliably exclude it. Seek urology early and arrange drainage under a defined plan. Repeated forceful catheter attempts are inappropriate. [13,14]

In a stable male patient with suspected urethral injury, retrograde urethrography and/or flexible urethroscopy can establish the injury. [13] The AUA favours urethrography before blind passage when meatal blood follows pelvic trauma. UK BOAST allows one gentle attempt by an experienced doctor, and urgent drainage in unstable patients may follow specialist direction. If passage is difficult, stop; do not inflate a balloon when position is uncertain. Use the local urological pathway rather than a blanket rule to catheterise every patient. [14,15]

Bladder injury needs the right investigation

Pelvic fracture with visible haematuria requires retrograde cystography, commonly CT cystography, unless an immediate operative indication supersedes imaging. Passive filling during routine excretory CT is inadequate to exclude rupture. Uncomplicated extraperitoneal rupture may be managed with drainage; traumatic intraperitoneal rupture requires operative repair. Bladder-neck involvement, intravesical bone, entrapment or associated rectal/vaginal injury generally requires operative management of an extraperitoneal rupture. Female urethral injury requires specialist endoscopic and vaginal assessment. [13]

Modern multidisciplinary treatment has changed the prospects of these injuries, but no single reassuring mortality figure applies to all open fractures. Haemorrhage, contamination, tissue loss and associated injuries still demand urgency.

Acetabular injury and definitive reconstruction

The socket is a different reconstructive problem

The acetabulum forms the socket of the hip. Its articular injury threatens congruity, stability and cartilage survival; a pelvic-ring injury primarily threatens ring stability and load transfer. They may coexist and both may occur during major trauma. An isolated acetabular fracture should therefore be distinguished from a ring disruption without being dismissed as physiologically unimportant.

A traumatic hip dislocation requires urgent reduction by an appropriate team, with analgesia or anaesthesia and documented neurovascular assessment. Associated femoral-neck injury or other contraindications must be considered before manipulation. CT and specialist review define the wall and column injury, fragments, marginal impaction and residual congruity. The Letournel-Judet system supplies the usual anatomical language for acetabular patterns. [16]

Definitive treatment may be nonoperative care, reduction and fixation, or a selected arthroplasty-based strategy. The decision considers joint congruity, stability, weight-bearing surface, bone quality, physiological reserve and the patient's functional goals. Complex reconstruction is concentrated in specialist services because it requires specific experience and coordinated infrastructure, not because acetabular injury lies outside trauma care.

When the patient is ready for fixation

Definitive surgery should follow control of bleeding and an assessment of physiological recovery. Consider temperature, coagulation, perfusion trends, transfusion need, respiratory status, associated brain or abdominal injury and the expected duration and burden of surgery. A calendar interval alone does not establish readiness, and normal blood pressure maintained by continuing support may conceal incomplete resuscitation.

BOAST recommends pelvic-ring reconstruction within 72 hours of physiological stabilisation when associated injuries allow. This should encourage timely care after recovery, while preserving the damage-control option for a patient who cannot yet tolerate definitive surgery. Stable patients do not automatically need a prolonged period of temporisation. [5]

Reconstruction may combine anterior plating or screws with posterior iliosacral or transsacral fixation; selected sacral injuries require lumbopelvic constructs. The posterior lesion, safe fixation corridors, soft-tissue condition and associated contamination govern the choice. A binder, anterior frame or apparently satisfactory anterior reduction does not demonstrate that posterior stability has been restored. [12,17]

Soft tissue can change the operation

Closed degloving, including a Morel-Lavallée lesion, may be concealed beneath initially intact skin. Swelling, fluctuance, bruising or altered skin sensation should prompt review. Skin viability, fluid collections and contamination can change incision placement and the timing of implants. Operative planning must include the envelope around the bone, not simply the radiographic fracture lines. [24]

The first day and the longer recovery

Use the first 24 hours to establish a coherent plan

By the end of the first day, the team should be able to state whether bleeding is controlled, what remains uncertain, how the ring is supported, and who owns each outstanding decision. The handover must include the binder-removal or replacement plan, pack count and re-exploration plan where relevant, urinary drainage, wound and contamination management, neurological findings and transfer arrangements.

Repeat the primary survey after deterioration and complete a tertiary survey when the patient can participate. Check the spine, hip joints, limbs and soft tissues again. Review haemoglobin and perfusion trends, renal function and urine output. Recurrent shock is a reason to reconsider all bleeding sources, including a source previously believed to be controlled.

Prevent avoidable complications

Pelvic injury and immobility increase venous thromboembolism risk. Reassess thrombosis and bleeding risk as the condition changes, use suitable mechanical measures, and start pharmacological prophylaxis when the balance permits under the trauma protocol. Do not carry an initial bleeding contraindication forward indefinitely without review. [19]

Plan pain control, pressure-area protection, nutrition, respiratory care and safe mobilisation. Document weight-bearing instructions for each limb, the reasons for restrictions, their intended duration and the review arrangements. Instructions must reflect the actual fracture, fixation and associated injuries rather than a standard restriction applied to every pelvis. [20]

Recovery extends beyond union

Follow-up should address walking, sitting tolerance, persistent pain, neurological recovery, bladder and bowel function, sexual health and psychological distress. Ask about these directly and sensitively; patients may not volunteer them. Rehabilitation requires realistic milestones and coordination with the patient's home circumstances, work and support network.

Older adults may sustain serious pelvic injury after relatively low-energy trauma, so a pelvic fracture is not universally evidence of a high-energy mechanism. Frailty, osteoporosis, anticoagulation and inability to mobilise change the assessment. Persistent pain after an apparent pubic-ramus fracture may indicate an unrecognised posterior injury. Children and pregnant patients require adapted multidisciplinary pathways rather than unmodified adult assumptions. [3,22]

The philosophy of pelvic trauma care

For me, the pelvis brings the central philosophy of major trauma into focus. We must understand the structure, read the physiology, anticipate associated injury and organise the people who can help. Temporary stabilisation buys an opportunity for treatment; it does not complete treatment. A good reconstruction restores anatomy, while good trauma care preserves life and makes meaningful recovery possible.

References

Clinical sources checked on 13 October 2026. Numbers in the text refer to the sources below. Guidance is interpreted alongside patient physiology, associated injuries and local expertise.

1. Holtenius J, Bakhshayesh P, Enocson A. The pelvic fracture - Indicator of injury severity or lethal fracture? *Injury*. 2018;49:1568-1571. doi:10.1016/j.injury.2018.06.016. [Source](#)
2. Bakhshayesh P, Weidenhielm L, Enocson A. Factors affecting mortality and reoperations in high-energy pelvic fractures. *Eur J Orthop Surg Traumatol*. 2018;28:1273-1282. doi:10.1007/s00590-018-2203-1. [Source](#)
3. Enocson A, Lundin A, Granqvist M. Pelvic injuries in elderly trauma patients: epidemiology, injury characteristics, in-hospital care and factors influencing mortality. *Arch Orthop Trauma Surg*. 2026;146:332. doi:10.1007/s00402-026-06506-x. [Source](#)
4. Coccolini F, Stahel PF, Montori G, et al. Pelvic trauma: WSES classification and guidelines. *World J Emerg Surg*. 2017;12:5. doi:10.1186/s13017-017-0117-6. [Source](#)
5. British Orthopaedic Association. BOASt The Management of Patients with Pelvic Fractures. January 2018. [Source](#)
6. National Institute for Health and Care Excellence. Fractures complex assessment and management. NG37. Recommendations on pelvic fractures and pelvic binders. [Source](#)
7. National Institute for Health and Care Excellence. Major trauma assessment and initial management. NG39. Recommendations on haemorrhage and imaging. [Source](#)
8. Rossaint R, Afshari A, Bouillon B, et al. The European guideline on management of major bleeding and coagulopathy following trauma. Sixth edition. *Crit Care*. 2023;27:80. doi:10.1186/s13054-023-04327-7. [Source](#)
9. Bakhshayesh P, Hullberg Risling D, Enocson A. Three Dimensional Quality Assessments of Applied Pelvic Binders. *Bull Emerg Trauma*. 2019;7:156-161. doi:10.29252/beat-070211. [Source](#)
10. Bakhshayesh P, Boutefnouchet T, Tötterman A. Effectiveness of non invasive external pelvic compression: a systematic review of the literature. *Scand J Trauma Resusc Emerg Med*. 2016;24:73. doi:10.1186/s13049-016-0259-7. [Source](#)
11. AO Foundation. AO Surgery Reference. Extraperitoneal pelvic packing for acute pelvic treatment. [Source](#)
12. AO Foundation. AO Surgery Reference. External fixation and traction for bilateral complete disruption of posterior arch. [Source](#)
13. European Association of Urology. EAU Guidelines on Urological Trauma. Urogenital trauma guidelines. Bladder and urethral trauma sections. Current online edition. [Source](#)

References continued

14. British Orthopaedic Association. BOAST The Management of Urological Trauma Associated with Pelvic Fractures. August 2016. [Source](#)
15. American Urological Association. Urotrauma Guideline. Amended 2020. Bladder and urethral trauma recommendations. [Source](#)
16. AO Foundation. AO Surgery Reference. Principles of acetabular fracture reduction. [Source](#)
17. AO Foundation. AO Surgery Reference. ORIF spinopelvic fixation for sacral fractures. [Source](#)
18. Eastern Association for the Surgery of Trauma. Pelvic Fracture Hemorrhage Update and Systematic Review. Practice management guideline. 2011. Listed as update in process when accessed. [Source](#)
19. National Institute for Health and Care Excellence. Venous thromboembolism in over 16s reducing the risk of hospital-acquired deep vein thrombosis or pulmonary embolism. NG89. Major trauma recommendations. [Source](#)
20. British Orthopaedic Association. BOAST Mobilisation and weightbearing after orthopaedic surgery or musculoskeletal injury. August 2024. [Source](#)
21. Patterson JT, Mayfield CK, Gary JL, et al. Pelvic binder radiography detects occult instability in cadaveric simulated lateral compression type I LC1 pelvic fractures. *Injury*. 2023;54:111067. doi:10.1016/j.injury.2023.111067. [Source](#)
22. AO Foundation. AO Surgery Reference. Stable ring fractures. Definition and assessment. [Source](#)
23. Burgess AR, Eastridge BJ, Young JW, et al. Pelvic ring disruptions: effective classification system and treatment protocols. *J Trauma*. 1990;30:848-856. doi:10.1097/00005373-199007000-00015. [Source](#)
24. AO Foundation. AO Surgery Reference. Patient assessment and diagnosis of acetabular fractures. [Source](#)
25. Coccolini F, Roberts D, Ansaloni L, et al. The open abdomen in trauma and non-trauma patients: WSES guidelines. *World J Emerg Surg*. 2018;13:7. doi:10.1186/s13017-018-0167-4. [Source](#)
26. Jansen JO, Hudson J, Cochran C, 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;330:1862-1871. doi:10.1001/jama.2023.20850. [Source](#)

CHAPTER 6

Spine and Spinal Precautions in Major Trauma Surgery

Philosophy of Major Trauma

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

The spine as the foundation of the body

I think of the spine as the central foundation of the body. The head rests above it, the thorax is organised around it, and the pelvis receives its load and transfers that load to the lower limbs. Yet this foundation must move. It allows us to turn towards another person, bend, sit, stand and balance while carrying the weight of the head and trunk.

This combination of support and movement explains much of spinal trauma. An injured segment may lose its ability to carry load safely, protect neural structures or maintain alignment. Our responsibility is to recognise these threats while treating the patient's other injuries. The purpose of spinal precautions is to preserve function during rescue, resuscitation, investigation and treatment.

Two questions should remain together throughout care: is the spinal column mechanically stable, and is the nervous system intact? A patient can have an unstable fracture with a normal neurological examination. Conversely, important spinal cord injury can occur without an obvious fracture on CT. Neither the scan nor the examination should be interpreted in isolation.

This chapter addresses adult major trauma, from initial protection to definitive treatment and rehabilitation. It develops the principles behind decisions; children require their own assessment and imaging pathways.

Anatomy that explains function and vulnerability

The cervical spine supports a relatively heavy head through a wide but bounded range of movement. Flexion, extension, lateral bending and rotation are shared between different joints. The upper cervical region makes a substantial contribution to rotation. The neck does not rotate through 360 degrees, and unrestricted movement is not a test of safety after injury.

The thoracic vertebrae form the posterior framework of the chest. Ribs articulate with the vertebral bodies and, for most ribs, the transverse processes; they are separate bones rather than extensions of those processes. The scapula glides over the thoracic wall through muscular support. Its skeletal connection to the axial skeleton is through the clavicle and sternoclavicular joint, rather than a direct scapula-to-spine joint.

The lumbar vertebrae accommodate substantial load and movement. Vertebral bodies, intervertebral discs, facet joints, ligaments and muscles work together. Cervical and lumbar lordosis and thoracic kyphosis distribute loading through a curved column. These normal curves must be distinguished from traumatic deformity. [1]

At the base, the sacrum connects the spine to the pelvic ring through the sacroiliac joints and their strong ligaments. The pubic symphysis completes the anterior ring, while the acetabula transmit load to the femoral heads. In quiet standing, the body's centre of mass is commonly described near, and anterior to, the upper

sacrum. Its position varies with posture and body proportions; it is not a fixed point at which body mass is concentrated.

The thoracic and abdominal organs occupy spaces supported by this framework, but they are not all suspended directly from the spine. Pleura, peritoneum, mesenteries, connective tissues, the diaphragm and abdominal wall have distinct roles. The architectural analogy helps us understand relationships; anatomical attachments still need to be described precisely.

Within the vertebral canal, the spinal cord continues from the medulla oblongata and usually ends as the conus medullaris around L1 to L2 in adults, with anatomical variation. Below it, descending lumbar, sacral and coccygeal roots form the cauda equina. Nerve roots leave the canal and contribute to peripheral nerves and plexuses. Discs are load-bearing structures, not components of the nervous system.

How the spinal column fails

Trauma applies combinations of compression, bending, tension, translation and rotation. The resulting damage depends on the direction and magnitude of force, bone quality, pre-existing disease and the structures that fail. A description of mechanism should lead us to look for the corresponding injury, rather than predetermine its severity.

Compression can produce a wedge fracture or a burst fracture. A burst fracture involves the posterior vertebral body wall and may displace fragments towards the canal. The word burst describes a fracture pattern; it does not mean that the vertebra literally explodes. Posterior tension-band injury must be assessed separately. [2]

Distraction separates structures that normally resist tension. Flexion can disrupt the posterior tension band, while hyperextension can fail the anterior tension band. Translation and rotation may disrupt the whole motion segment. AO Spine broadly distinguishes compression injuries, tension-band failures and displacement injuries as types A, B and C. These categories help describe what has failed. [2]

There is no safe general rule that flexion injuries are less serious than extension injuries, or that distraction is always the most severe pattern. A flexion-dislocation can be profoundly unstable; an extension injury in an ankylosed spine may also be devastating. Neurological injury and mechanical instability require their own assessment.

In an ankylosed spine, long rigid segments can transmit force across a fracture like long bones. A seemingly modest fall may therefore cause a major unstable injury. Existing kyphosis must be supported in its usual alignment. Forcing such a patient into an assumed straight or neutral position may displace the injury. [3]

Protection begins with the first contact

Spinal care begins during airway assessment and continues through the entire trauma pathway. It cannot be postponed until disability or exposure. Oxygenation, ventilation and haemorrhage control also protect the spinal cord by sustaining its perfusion.

Use the trauma network's agreed spinal protection protocol. During airway intervention, a trained assistant provides manual support as indicated. A collar must not obstruct airway management; reassess the airway after fitting it. If a device compromises the airway or cannot accommodate deformity, adapt protection with experienced assistance. Lifesaving treatment takes priority. [4]

I regard every transfer as a clinical intervention. Before moving the patient, identify who is directing the movement, the alignment to maintain, the equipment needed and the position of lines, drains and injured

limbs. Explain the movement to an awake patient. Analgesia and reassurance help the patient cooperate and reduce avoidable struggling.

A collar is only one component of protection. It does not eliminate movement or protect the thoracolumbar spine. Check fit, skin and pressure points. Avoid leaving the patient on a hard extrication board; NICE advises against using a longboard as the transport surface. [4]

Log rolling produces movement and should have a defined purpose. Use trained, coordinated handling and the locally agreed transfer method. An unstable pelvis, severe chest injury or physiological deterioration may change the safest approach. Repeated turns merely to reproduce an examination add little value.

Modern extrication guidance emphasises timely rescue with gentle handling. Attempts to abolish every small movement should not prolong dangerous entrapment or prevent essential care. The appropriate method depends on the scene, the patient's condition and trained rescuers' assessment. [5]

Assessment throughout the primary survey

The airway team needs to know whether cervical injury is suspected. During breathing assessment, consider whether respiratory weakness reflects cord injury, chest injury, sedation or a combination. During circulation assessment, hypotension must trigger a search for bleeding and other causes of shock, even when a spinal injury is already known.

At disability, document consciousness and a focused examination of limb movement and sensation as early as resuscitation allows. At exposure, inspect for wounds, bruising and deformity while protecting warmth and dignity. Later examination should record spinal pain and tenderness, neurological symptoms and the circumstances that make the findings unreliable.

Sedation, intoxication, brain injury, severe pain and distracting limb injuries can limit assessment. Record these limitations explicitly. The phrase neurologically intact must not be used when the patient could not be examined adequately. Repeat the assessment when participation improves.

New weakness, altered sensation or worsening pain after movement or treatment requires immediate reassessment. Check airway, oxygenation and perfusion, maintain appropriate protection and escalate to the spinal team. A change in function is a clinical event, even before repeat imaging explains it.

A neurological record that can show change

The International Standards for Neurological Classification of Spinal Cord Injury, or ISNCSCI, provide a structured examination. The familiar expression ASIA chart refers to this system, developed through ASIA and ISCoS. Use the current worksheet and trained examiners. The official resources now include the ninth edition published in 2026. [6]

The assessment records bilateral key muscle strength and sensory findings, including light touch and pinprick. Sacral assessment includes S4 to S5 sensory function, deep anal pressure and voluntary anal contraction where appropriate to the formal examination. Sacral sparing is central to distinguishing complete from incomplete SCI. The neurological level and ASIA Impairment Scale grade are derived from the findings; they are not substitutes for recording them. [6]

The UK BOAST for traumatic SCI calls for a detailed ISNCSCI record within two hours of admission, weekly, and before and after major interventions, alongside daily general neurological review. If resuscitation or inability to participate prevents completion, document this and complete it as soon as feasible. [7]

The most useful record is one that permits comparison. Record the time, examiner, sedation and confounding injuries. Communicate deterioration directly rather than relying on a chart entry to be noticed. Examination should also include relevant bladder, bowel and perineal symptoms; limb movement alone does not describe all neurological function.

Imaging and clearance

In adult major trauma, multidetector CT is the principal initial investigation for suspected bony spinal injury. Review alignment, fractures and indirect signs of ligament failure. Whole-body trauma CT requires appropriate spinal coverage and multiplanar reconstructions; the label whole body does not itself prove that every spinal segment has been evaluated. [3,4]

MRI answers different questions. It can demonstrate cord injury, disc disruption, ligament injury, epidural haematoma and neural compression. Neurological findings attributable to spinal cord injury require MRI after CT even if CT is normal. Equivocal imaging and painful spinal ankylosis may also require MRI and specialist review. For confirmed traumatic SCI, BOAST recommends whole-spine MRI after initial CT once safe. [3,4,7]

Imaging must be possible without abandoning monitoring or resuscitation. A patient who cannot safely tolerate the transfer or scan needs a coordinated plan between trauma, anaesthesia, radiology and spinal services. Conversely, an urgent neurological problem should not drift into an unprioritised imaging queue.

Clearance is a documented decision made under the agreed pathway. Selected alert patients may be assessed with a validated clinical decision rule; high-risk patients should not be asked to demonstrate neck movement as an informal test. Persistent clinical concern or abnormal neurology requires further evaluation.

For an obtunded adult, MRI is not universally mandatory after a negative high-quality cervical CT. EAST conditionally supports CT-based clearance alone, although the evidence quality is very low. Local policy, image adequacy, expert interpretation and any clinical-radiological discrepancy determine the decision. Record who authorised clearance and what restrictions remain. [8]

Classification should support the decision

A classification gives the team a common language. Its clinical value lies in connecting morphology, ligament integrity and neurological findings to the patient's management. A score cannot account fully for physiology, frailty, bone quality, associated injuries or the feasibility of rehabilitation.

System	Main application	Principal information
SLIC	Subaxial cervical injuries	Injury morphology, disco-ligamentous integrity and neurological status. [9]
TLICS	Thoracolumbar injuries	Morphology, posterior ligamentous complex integrity and neurological status. [10]
AO Spine	Regional spinal trauma classification	Morphology, neurological findings and relevant modifiers; the subaxial cervical system also describes facet injury. [2,11]
Sacral systems	Sacral and spinopelvic injury	Denis zones describe location relative to foramina; AO Spine also distinguishes effects on pelvic and spinopelvic stability. [12]

SLIC means Subaxial Injury Classification and Severity Scale; TLICS means Thoracolumbar Injury Classification and Severity Score. SLIC is not an upper cervical classification. Injuries of the occiput, atlas and axis need their own anatomical and ligamentous assessment. [9,10]

For the sacrum, AO type A injuries are lower sacrococcygeal injuries without loss of pelvic or spinopelvic stability. Type B injuries affect posterior pelvic stability, while type C injuries affect spinopelvic stability. A U-shaped injury can disconnect the load-bearing spine from the pelvic ring and requires particular attention. Sacral injury should prompt discussion between the spinal and pelvic teams when their responsibilities overlap. [12]

Cord perfusion and the distinction between two forms of shock

The initial mechanical injury may be followed by secondary damage. We cannot reverse the moment of impact, but we can address continuing compression, hypoxaemia and inadequate perfusion. This is why the resuscitation plan belongs within spinal treatment.

Neurogenic shock is haemodynamic failure caused by loss of sympathetic control, usually after a high spinal cord injury. Hypotension, vasodilatation and relative bradycardia may occur. Spinal shock describes transient depression of neurological function and reflexes below the injury, often with early flaccidity and areflexia. The terms describe different phenomena and can coexist. [13]

Do not attribute hypotension to neurogenic shock before investigating haemorrhage and other causes. A patient can have both spinal cord injury and major bleeding. Blood replacement, source control and critical-care support must be coordinated; a normal-looking pulse rate does not exclude shock.

The 2024 AO Spine and Praxis guideline suggests augmenting mean arterial pressure to a lower limit of 75 to 80 mmHg, without actively augmenting beyond an upper limit of 90 to 95 mmHg, for three to seven days after acute traumatic SCI. These are weak recommendations based on very-low-quality evidence. They require individual critical-care decisions, particularly with associated haemorrhage, brain injury or cardiovascular disease. The upper limit is not an instruction to lower a spontaneously higher pressure. [14]

Under NICE guidance, high-dose methylprednisolone is not recommended for neuroprotection in acute traumatic SCI. Treatment should follow the specialist pathway rather than an assumed universal drug protocol. [4]

Choosing treatment and its timing

Mechanical stability, neurological status and the patient's physiology determine the treatment discussion. Selected stable injuries can be managed without surgery. The plan should state permitted movement, mobilisation, any collar or brace, its care and duration, and the arrangements for clinical and imaging review. Non-operative treatment requires an active plan. [3]

Surgery may address persistent neural compression, instability, displacement or a substantial risk of progressive deformity. Its objectives should be explicit: what structure requires decompression, what alignment requires restoration, and what stability is needed for safe care and rehabilitation? The operative approach follows the lesion and the patient.

The 2024 AO Spine and Praxis guideline recommends offering decompressive surgery within 24 hours of injury for adults with acute SCI when medically feasible. This is a strong recommendation supported by moderate-quality evidence. It does not establish a universal ultra-early threshold below 12 hours, and the 24-hour interval must not become a reason to wait when neurology is deteriorating. [15]

In polytrauma, the spinal surgeon, trauma team and anaesthetist must agree the sequence of intervention. Ongoing haemorrhage, chest injury and the consequences of prone positioning may alter what is immediately achievable. Necessary delay should have a stated reason, continuing protection and a time for reassessment. Once the patient can tolerate the indicated treatment, avoid preventable organisational delay.

Decompression and stabilisation solve related but different problems. A laminectomy is not the automatic operation for every neurological deficit. Removing posterior elements may not address anterior compression and can affect stability. Reduction, fixation, decompression or a combination must be selected for the actual injury.

Cauda equina and conus injury

The conus medullaris is the terminal spinal cord; the cauda equina consists of descending nerve roots below it. Injury near the thoracolumbar junction can affect the cord, conus and roots in different combinations. More distal canal compromise can injure the cauda equina without injuring the spinal cord itself.

Cauda equina syndrome is an emergency involving dysfunction of these roots. Thinking of pressure threatening nerves can be a useful analogy, but CES is not literally a limb compartment syndrome. In trauma, compression, displacement, stretching or direct root injury may contribute. The investigation must identify the lesion and whether a surgically remediable cause remains.

Ask about new difficulty initiating urination, altered awareness of bladder filling or urinary flow, retention or overflow, saddle sensory change, bowel disturbance and sexual dysfunction. Examine lower-limb neurology and assess sacral function when indicated. Do not wait for every feature to appear or for painless retention to develop. Suspected compression requires urgent MRI and spinal review. [16]

A bladder scan is an adjunct. A post-void residual below 200 mL does not exclude CES. Monitoring and appropriate catheterisation can protect the bladder from overdistension, but they do not prevent CES or replace investigation. In pelvic trauma, possible urethral injury also affects the catheterisation plan. [16]

When a sacral fracture causes CES, reduction and stabilisation may be central to treatment. The 2023 Italian Pelvic Trauma Association consensus supports reduction as early as possible; direct decompression depends on the neurological trajectory and demonstrable compression. A deficit without imaging evidence of root compression is not, by itself, an indication for laminectomy. This is expert consensus with limited evidence, and does not establish a universal hour-based rule for every sacral injury. [17]

Rehabilitation starts during acute care

The outcome of spinal trauma extends beyond fracture union and an acceptable postoperative image. Breathing, hand function, transfers, sitting balance, continence, pain and the ability to participate in ordinary life may matter as much as walking. Ask the patient which functions and activities matter most to them.

Early specialist rehabilitation should address skin protection, positioning, respiratory care, joint movement, pain, nutrition, bowel and bladder management, and psychological support. Assess venous thromboembolism risk and agree prophylaxis with the teams managing bleeding and surgery. Mobilisation must reflect spinal stability, associated injuries and physiological tolerance. [7,18]

Spinal cord injury may affect sexual function and cause orthostatic hypotension or autonomic dysreflexia. The patient and those supporting them need appropriate education and a clear route for urgent advice. Rehabilitation needs should be reassessed as function, complications and circumstances change. [18]

For patients without cord injury, persistent pain, loss of alignment or declining function still require attention. Establish who will review the fracture, whether further imaging is required and when restrictions can change. Advice about driving, work and activity should be individualised rather than inferred from a fixed healing date.

Orthopaedic spinal surgeons and neurosurgeons contribute overlapping expertise. The service name matters less than access to the required competence, timely decision-making and clear responsibility. Intradural injury, neural compression, instability and complex pelvic involvement may require different combinations of specialists.

The responsibility at handover

Every handover should convey the injured levels, current neurological findings and their trend, the stability assessment, permitted positioning, outstanding imaging, perfusion and respiratory needs, and the named team responsible for the next decision. Include bladder, bowel and skin care when relevant. A plan that is understood only by the operating surgeon is incomplete.

For me, the philosophy of spinal trauma care returns to the foundation with which this chapter began. We are protecting the structure through which a person moves and the neurological function through which they act and experience the world. A good reconstruction should make safe care and useful recovery possible. The responsibility continues through rehabilitation and into the patient's life beyond the hospital.

References

Clinical sources checked on 13 October 2026. Numbered citations identify the sources supporting clinical recommendations and classification terminology. Interpret recommendations with the patient's physiology, associated injuries and current trauma-network protocols.

1. American Academy of Orthopaedic Surgeons. Spine Basics. OrthoInfo. Anatomy and spinal structures. [Source](#)
2. AO Foundation. AO Spine thoracolumbar injury classification system. AO Surgery Reference. [Source](#)
3. British Orthopaedic Association. BOAST Assessment of the Spine in the Trauma Patient. April 2025. [Source](#)
4. National Institute for Health and Care Excellence. Spinal injury assessment and initial management. NG41. 2016. Recommendations. [Source](#)
5. Faculty of Pre-hospital Care, Royal College of Surgeons of Edinburgh. Extrication following a motor vehicle collision. Consensus statement. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine. 2025. doi:10.1186/s13049-024-01312-z. [Source](#)
6. Rupp R, Biering-Sørensen F, Burns S, et al. International Standards for Neurological Classification of Spinal Cord Injury. Ninth edition 2026. Topics in Spinal Cord Injury Rehabilitation. 2026;32(4):141-168. doi:10.46292/sci26-00067. Official worksheet and resources. [Source](#)
7. British Orthopaedic Association. BOAST The Management of Traumatic Spinal Cord Injury. November 2022. [Source](#)
8. Patel MB, Humble SS, Cullinane DC, et al. Cervical spine collar clearance in the obtunded adult blunt trauma patient. EAST practice management guideline. Journal of Trauma and Acute Care Surgery. 2015;78:430-441. [Source](#)
9. Vaccaro AR, Hulbert RJ, Patel AA, et al. The subaxial cervical spine injury classification system. A novel approach to recognise the importance of morphology, neurology and integrity of the disco-ligamentous complex. Spine. 2007;32:2365-2374. [Source](#)

References continued

10. Vaccaro AR, Lehman RA Jr, Hurlbert RJ, et al. A new classification of thoracolumbar injuries. The importance of injury morphology, posterior ligamentous complex integrity and neurologic status. *Spine*. 2005;30:2325-2333. [Source](#)
11. AO Foundation. AO Spine subaxial cervical spine injury classification system. AO Surgery Reference. [Source](#)
12. AO Foundation. AO Spine sacral injury classification system. AO Surgery Reference. [Source](#)
13. Faculty of Intensive Care Medicine. What is the difference between neurogenic and spinal shock. Case of the Month 38. April 2023. [Source](#)
14. Kwon BK, Tetreault LA, Martin AR, et al. A clinical practice guideline for acute spinal cord injury. Recommendations on hemodynamic management. *Global Spine Journal*. 2024;14(3 Suppl):187S-211S. doi:10.1177/21925682231202348. [Source](#)
15. Fehlings MG, Tetreault LA, Hachem L, et al. An update of a clinical practice guideline for acute spinal cord injury. Recommendations on the role and timing of decompressive surgery. *Global Spine Journal*. 2024;14(3 Suppl):174S-186S. doi:10.1177/21925682231181883. [Source](#)
16. NHS England Getting It Right First Time. National Suspected Cauda Equina Syndrome Pathway. Revised March 2026. [Source](#)
17. Aprato A, Branca Vergano L, Casiraghi A, et al. Consensus for management of sacral fractures, with a focus on the role of decompression. *Journal of Orthopaedics and Traumatology*. 2023;24:46. doi:10.1186/s10195-023-00726-2. [Source](#)
18. National Institute for Health and Care Excellence. Rehabilitation after traumatic injury. NG211. 2022. Recommendations on spinal cord injury and multidisciplinary rehabilitation. [Source](#)

CHAPTER 7

Plexus Injuries

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

Plexus injuries can determine how a patient lives long after fractures have united and the immediate danger has passed. An arm may remain weak or insensate; a patient with a reconstructed pelvis may still struggle to stand or walk. In major trauma, we must therefore recognise neurological injury early and preserve the opportunity for recovery and reconstruction.

This chapter concerns traumatic injuries of the brachial, lumbar and sacral plexuses, including the axillary region and the relationship between the lower plexuses and the injured pelvis. The central questions are where the nerve injury lies, what structures remain intact, whether recovery is occurring, and when specialist intervention is needed.

7.1 Mechanism and clinical priorities

Traction is an important mechanism. Sudden separation of the head and shoulder, forcible displacement of the arm, or displacement across the pelvic ring can stretch neural structures beyond their tolerance. The result may range from transient conduction block to rupture or root avulsion. Penetration, compression, crush and associated vascular injury can also damage nerves; the mechanism alone cannot establish the structural grade. [1,2]

The initial trauma priorities remain resuscitation, haemorrhage control and treatment of immediate threats to the limb. Neurological assessment should begin as soon as the patient's condition permits and should continue through reduction, fixation, transfer and rehabilitation. A patient who cannot participate in examination has an incomplete assessment, not a normal one. [3]

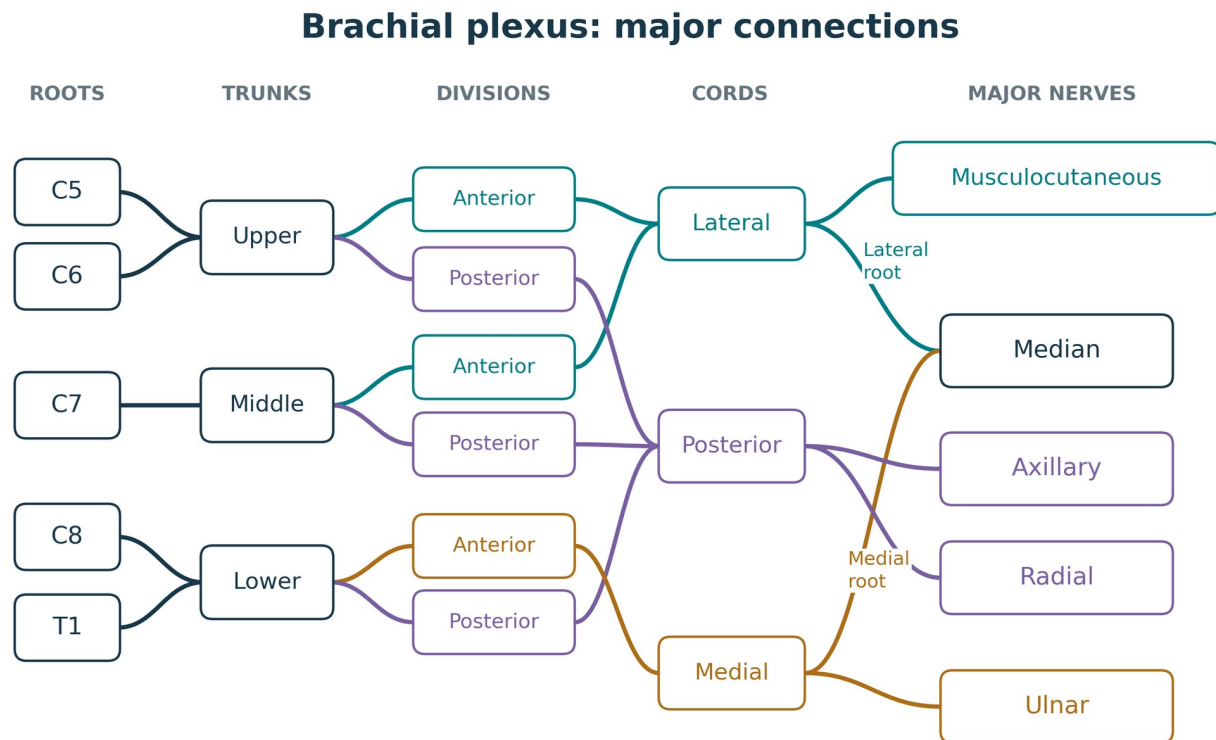
7.2 What constitutes a plexus

A somatic nerve plexus is a network formed by anterior, or ventral, rami after spinal nerves have emerged from the vertebral column. Fibres are redistributed through this network into peripheral nerves. Consequently, injury to one plexus element can affect several muscles and sensory territories that belong to different terminal nerves. [2,4]

The recognised upper-limb network is the brachial plexus. Its infraclavicular portion extends into the axilla; the axillary nerve is one of its branches. In the lower limb, the lumbar and sacral plexuses communicate through the lumbosacral trunk. "Lumbopelvic" describes their regional relationship to the spine and pelvis; it does not identify an additional, separate plexus. [4–6]

7.3 The brachial plexus

The usual brachial plexus receives C5–T1 anterior rami. These form three trunks, six divisions and three cords before giving rise to the major terminal nerves. C5 and C6 form the upper trunk, C7 continues as the middle trunk, and C8 and T1 form the lower trunk. Figure 7.1 shows the main connections; smaller branches and anatomical variants have been omitted. [2,4]



Roots here are the anterior (ventral) rami of C5–T1.

Major connections only; side branches and anatomical variants are omitted. Not to scale.

Figure 7.1 Brachial plexus. Major connections from C5–T1 anterior rami to the terminal nerves. Smaller branches and variants are omitted. Original schematic; references 2 and 4.

Clinically, a proximal plexus injury may produce a pattern involving several peripheral nerves. Upper plexus involvement can compromise shoulder control and elbow flexion; lower plexus involvement may substantially impair hand function. Severe trauma can affect the whole plexus or produce mixed injuries at several levels. Examination must map the actual deficit rather than assume a uniform pattern from the mechanism. [1,2]

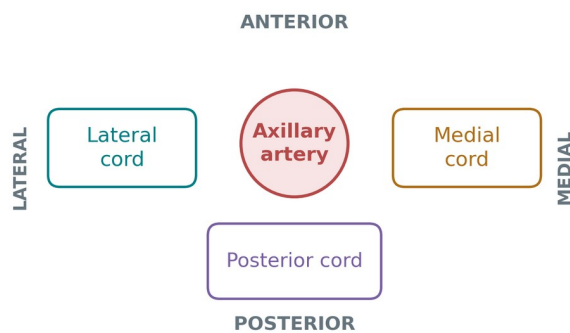
7.4 The axillary region and axillary nerve

The cords are named by their relationship to the second part of the axillary artery. This close association matters when shoulder-girdle trauma combines neurological loss with vascular injury. The axillary nerve usually carries C5–C6 fibres from the posterior cord. It passes through the quadrangular space and around the surgical neck of the humerus, supplying deltoid, teres minor and a patch of skin over the lateral shoulder. [4,6]

Brachial plexus in the axillary region

A. Cord positions around the artery

Simplified transverse view, looking distally

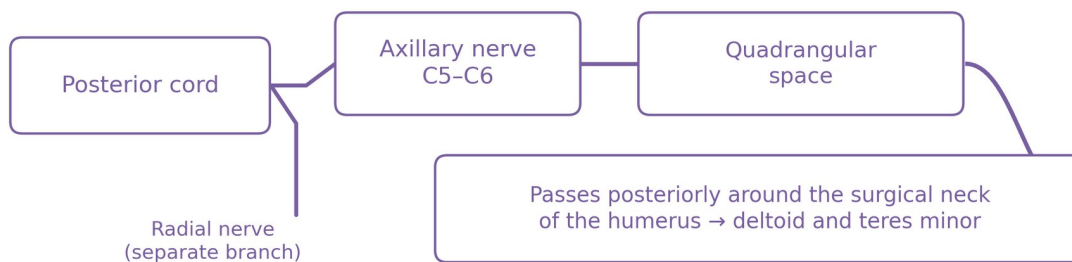


Anatomical reference

Cord names describe their relationship to the second part of the axillary artery.

This is the infraclavicular brachial plexus. "Axillary plexus" is not a separate standard anatomical plexus.

B. Axillary nerve: simplified course



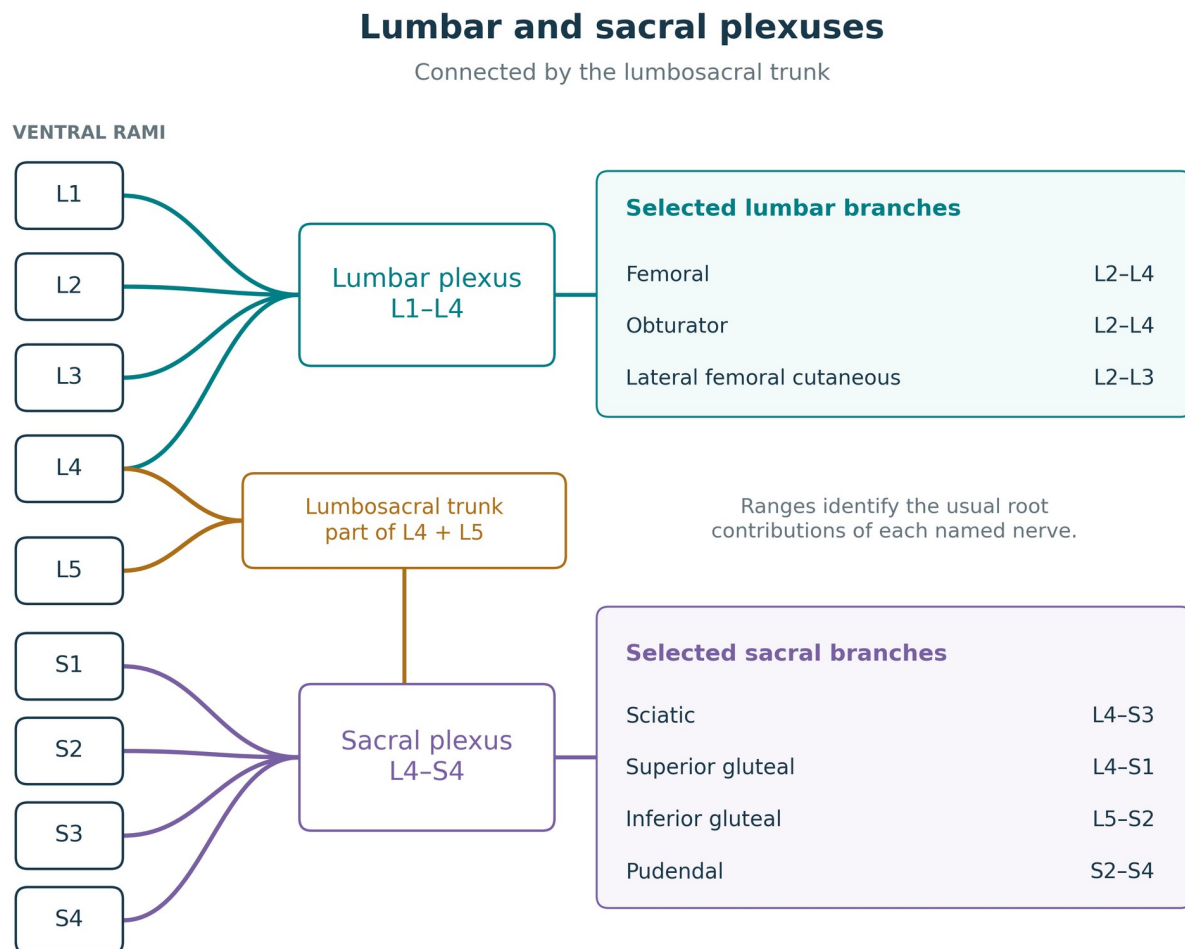
Relationships and course are schematic; the course panel is not a cross-sectional view.

Figure 7.2 Axillary region of the brachial plexus. The cords are shown relative to the second part of the axillary artery; the axillary nerve is a terminal branch. Original schematic; references 4 and 6.

After shoulder dislocation or proximal humeral injury, assess axillary nerve function alongside the rest of the plexus and the circulation. Pain and instability may limit active testing. Record the limitation and repeat the examination when safe; sensation over the lateral shoulder alone does not constitute a complete assessment of axillary nerve function. [3,6]

7.5 Lumbar and sacral plexuses in pelvic trauma

The lumbar plexus is formed mainly by L1-L4 within psoas major, sometimes with a T12 contribution. Part of L4 joins L5 as the lumbosacral trunk, which contributes to the sacral plexus, L4-S4, on the anterior surface of piriformis. Femoral and obturator nerves arise from the lumbar plexus; the sciatic nerve arises from the sacral plexus. [5,17]



Selected branches only; variants (including T12 input to the lumbar plexus) are omitted.

Figure 7.3 Lumbar and sacral plexuses. Part of L4 joins L5 as the lumbosacral trunk. Selected branches are labelled with usual root contributions. Original schematic; references 5 and 17.

Pelvic-ring disruption, sacral injury and regional haematoma may injure these structures. A sciatic deficit associated with acetabular or hip trauma may instead represent an individual nerve lesion. Localisation is essential: “pelvic nerve injury” is a starting description, not a final diagnosis. [7,8]

7.6 The structural severity of nerve injury

Seddon's terms describe different forms of injury, not simply different degrees of weakness. A completely paralysed limb on the first examination does not, by itself, prove that its nerves are divided. Conversely, an apparently continuous nerve may contain severe internal disruption. [9,10]

Neurapraxia is conduction block with preserved axonal continuity, often associated with focal myelin disturbance. Recovery is generally expected as conduction is restored. We should use this diagnosis with evidence and follow-up, rather than as reassurance for every closed traction injury. [10]

Axonotmesis involves interruption of axons and distal Wallerian degeneration. It may affect some or all axons in an injured segment. The supporting connective tissues are preserved to different degrees, so visible outer continuity does not guarantee an intact pathway for regrowth or complete recovery. [9,10]

Neurotmesis describes complete structural interruption of the nerve. It can follow sharp transection or severe blunt disruption. Useful spontaneous recovery across complete discontinuity is not expected, and reconstructive assessment is required. [10]

Table 7.1 Sunderland grades and supporting structures [9]

Grade	Structural disruption	Common grouping
I	Conduction or myelin disturbance; axon continuous	Neurapraxia
II	Axon interrupted; connective-tissue pathways preserved	Axonotmesis
III	Axon and endoneurium disrupted; perineurium preserved	Axonotmesis
IV	Axon, endoneurium and perineurium disrupted; epineurium continuous	Axonotmesis
V	Entire nerve architecture interrupted	Neurotmesis

Mixed grades can coexist within the same nerve or plexus. Prognosis also depends on the distance to the target muscle, associated ischaemia and scarring, and the time during which the muscle remains denervated. Clinical progression, imaging and neurophysiology must be interpreted together. [1,9]

7.7 Root avulsion and the level of injury

Preganglionic injury lies proximal to the dorsal-root ganglion; postganglionic injury lies distal to it. In root avulsion, the root is torn from the spinal cord. This is distinct from rupture farther along the plexus. Conventional grafting requires a usable proximal nerve source, which an avulsed root does not provide. Other reconstruction, including nerve transfers, may still be possible. [2,11]

Nerve injury: structure determines recovery

Simplified longitudinal sections through a peripheral nerve

Teal line: axon · Blue segments: myelin · Outer outline: nerve envelope

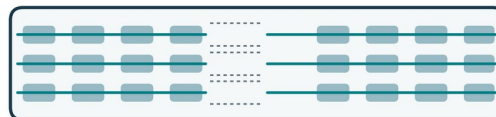
Neurapraxia

Axon remains continuous.
Conduction block may recover.



Axonotmesis

Axon continuity is lost.
Connective tissue: variable.



Axon loss;
supporting tissue
varies by grade

Dashed supporting tubes are illustrative: preservation differs in Sunderland grades II-IV.

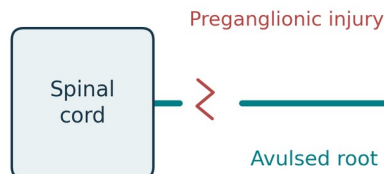
Neurotmesis

Complete structural disruption;
spontaneous useful recovery
is not expected.



Loss of overall
nerve continuity

Root avulsion: a distinct proximal injury



Preganglionic injury

A root is torn from the spinal cord.
There is no usable proximal root stump
for conventional graft repair to the cord.

Avulsed root

Specialist reconstruction may use nerve transfers.

Not to scale. Mixed injury grades can coexist within one plexus; clinical recovery also depends on distance and time.

Figure 7.4 Structural patterns of nerve injury. Root avulsion is shown separately from peripheral nerve injury grades. The drawings simplify the initial structural lesion and do not depict subsequent distal degeneration. Original schematic; references 9-11.

Horner syndrome or other findings suggesting proximal involvement should increase concern, but no isolated sign proves avulsion. Severe traction can produce both preganglionic and postganglionic lesions. Specialist localisation helps identify which components could recover and which require reconstruction. [2,11]

7.8 Assessment in the multiply injured patient

Examine the whole patient before assigning weakness to a plexus. Brain, spinal cord, root, cauda-equina, peripheral nerve, muscle and tendon injuries may coexist. Pain, sedation and unstable fractures can make an otherwise meaningful motor test unreliable. The examination should state what was tested, what was found and what could not be tested. [2,7]

Document individual movements and muscle power, sensory territories, relevant reflexes and vascular findings. Record a comparable neurological examination at the first opportunity, after limb interventions, and before and after relevant surgery. Document the time and the examiner. The pattern and evolution of findings are more useful than an entry stating only “neurovascular status checked.” [3]

Table 7.2 Selected functions to document [2,4,5,7]

Region	Examples of motor assessment	Examples of sensory assessment
Shoulder and arm	Deltoid contraction; external rotation; elbow flexion and extension	Lateral shoulder; lateral and medial forearm
Wrist and hand	Wrist and finger extension; thumb opposition; finger abduction	Median, ulnar and radial territories assessed separately
Hip and knee	Hip flexion, adduction and abduction; knee extension and flexion	Anterior and lateral thigh; medial leg
Ankle and foot	Dorsiflexion, eversion, plantarflexion and great-toe extension	Dorsal foot, first web space, lateral border and sole

These are screening examples, not isolated diagnostic tests. Interpret findings by root, plexus and peripheral-nerve distribution, and test only within safe movement limits.

An ischaemic limb, an expanding haematoma or compartment syndrome needs urgent assessment and treatment alongside the neurological problem. Reduce a dislocation associated with nerve injury immediately through the appropriate trauma pathway, and repeat the examination afterwards. [3]

After pelvic or spinal trauma, new saddle sensory change, sphincter disturbance, or bilateral or progressive neurological loss requires urgent assessment for spinal, cauda-equina or sacral-root injury. These findings must not be explained away as an uncomplicated limb plexopathy. [7]

7.9 Investigation and early specialist advice

Investigation should answer a clinical question: is the lesion in continuity, is a root avulsed, is there compression, and which targets retain a reasonable prospect of reinnervation? Trauma CT defines associated skeletal injury; vascular imaging follows the clinical concern for arterial damage. Dedicated MRI of the relevant spine and plexus, including MR neurography where available, may clarify the neural lesion. Specialists may select CT myelography when additional root detail is required. [1,7,9]

Electromyography and nerve-conduction studies help localise injury, identify axonal loss and follow reinnervation. A baseline study is commonly informative from approximately three to four weeks, with repeat assessment according to the clinical course. Very early testing may underestimate axonal damage. Referral, treatment of compression and indicated exploration should not wait for an EMG appointment. [1]

Preserved sensory nerve action potentials despite sensory loss may support a preganglionic lesion, whereas reduced responses after degeneration has developed support a postganglionic lesion. Mixed injuries and the timing of testing complicate this distinction; a single result should not overrule the full assessment. [2]

The UK BOAST standard distinguishes early specialist advice from the timing of reconstruction. Seek formal advice within 24 hours for a penetrating or lacerating injury with neurological deficit, and for peripheral nerve injury when associated fracture surgery is not indicated. Seek advice before planned internal fixation when a fracture is associated with nerve injury. A damaged nerve found during surgery, or a persistent new postoperative deficit after appropriate simple measures, requires immediate advice. [3]

Referral should include the mechanism, serial neurological findings, vascular status, imaging, associated fractures and the proposed operative plan. The receiving team needs enough information to coordinate nerve care with skeletal stabilisation and soft-tissue treatment. A named team and an agreed review date make observation an active treatment plan.

For a closed stretch injury, recovery may justify a period of observation under a specialist. This should include defined clinical milestones and a decision point for further investigation or reconstruction. The possibility of recovery is a reason to monitor carefully; it is not a reason to lose the patient from follow-up.

7.10 Reconstruction and the limits of waiting

Specialist nerve surgery may involve plastic and reconstructive surgeons, hand surgeons, orthopaedic surgeons or neurosurgeons with appropriate training. The service needs access to neurophysiology, imaging, rehabilitation and the trauma teams treating the associated injuries. Competence in major nerve reconstruction is more important than the name of the parent specialty.

The operation depends on the lesion. Neurolysis may release a selected nerve from constricting scar. Direct repair joins suitable divided ends without tension. A nerve graft bridges a defect when appropriate proximal and distal targets exist. A nerve transfer redirects a functioning donor nerve or fascicle to a useful recipient, sometimes shortening the distance to the target muscle. The cost to donor function must be considered. [1,11,12]

Timing is individual. Sharp division, compression and suspected avulsion require prompt specialist decisions. For closed stretch or blunt brachial plexus injuries, a systematic review found generally better outcomes when reconstruction took place within six months. A period of about three months may allow evidence of spontaneous recovery to emerge in selected cases. These intervals are not instructions to postpone referral, nor universal deadlines applicable to every nerve injury. [13]

When nerve reconstruction cannot restore the desired function, selected tendon transfers or functioning muscle transfers may offer further options. The discussion should identify a practical goal, such as useful elbow flexion, a stable shoulder or improved grasp, and explain the uncertainty, rehabilitation burden and potential donor morbidity. [1]

7.11 Reconstruction of the lower plexus

Traumatic lumbosacral plexus reconstruction has a smaller and less consistent evidence base than brachial plexus reconstruction. Lesions may combine compression, traction and avulsion in patients with substantial pelvic, vascular and soft-tissue injury. Reports describe selected surgical improvement, but small retrospective series cannot establish a standard operation or promise reliable recovery. [8,14]

Some patients recover without nerve reconstruction; others have lasting deficits. Injury pattern matters, and published recovery percentages should not be applied uncritically to an individual patient. Severe traction and avulsion require particular caution when discussing prognosis. [8]

Expertise is concentrated in specialist services. Lower-plexus surgery is available in centres that explicitly include lumbosacral reconstruction in their practice, including the Royal National Orthopaedic Hospital. Access should therefore follow regional referral pathways, without assuming that geography alone determines whether a patient can be assessed. [15]

7.12 Rehabilitation and the patient's future

Rehabilitation begins while the definitive neurological prognosis is still uncertain. Protect an insensate limb from pressure and thermal injury; maintain safe joint movement; support weak joints and prevent avoidable contracture. Exercise and splintage must respect associated fractures, soft-tissue injuries and any nerve repair. Orthoses may support the wrist or assist foot clearance when ankle dorsiflexion is weak. [7,10,16]

Neuropathic pain may persist even when the limb is numb. Pain assessment should distinguish neural symptoms from ongoing mechanical or vascular problems and should address sleep, mood and participation in therapy. Rehabilitation and pain specialists can help tailor treatment and monitor its effect. [10]

The patient also needs practical preparation for daily life: washing and dressing, transfers, walking, work and family responsibilities. Goals should be agreed with the patient and reviewed as function changes. Psychological support and occupational rehabilitation belong within the treatment plan, particularly when recovery is prolonged or incomplete. [16]

Follow-up should connect the original injury to present function. The record should show changes in power, sensation, pain, joint range and meaningful activities, together with relevant neurophysiology. A planned review also needs a route for earlier reassessment if weakness, pain or sensory loss progresses.

7.13 The philosophy of care

In major trauma, physiology determines our immediate priorities. Once those priorities are being addressed, we must also think about the life the patient will return to. A technically successful fracture reconstruction does not answer every question about the limb.

For plexus injuries, good judgement requires careful examination, an honest account of uncertainty and timely access to specialist knowledge. We should avoid promising spontaneous recovery simply because the injury was closed, and avoid assuming that a profoundly weak limb has no reconstructive possibility.

Our responsibility is to preserve options while helping the patient understand them. That begins in the trauma bay and continues through reconstruction, rehabilitation and the practical work of regaining independence.

Figures and scope

Figures 7.1–7.4 are original educational schematics prepared for this chapter using the anatomical and clinical references below. They show typical relationships, omit selected branches and variants, and are not to scale. They are not patient photographs or operative planning images. The chapter addresses adult traumatic plexus injury; birth-related palsy requires a separate pathway.

References

1. American Academy of Orthopaedic Surgeons. Brachial Plexus Injuries. OrthoInfo. Adult traumatic injury, diagnosis and treatment. [Read source](#)
2. Abraham A, et al. Traumatic Brachial Plexopathy. AAPM&R KnowledgeNow. Updated 5 June 2025. General anatomy and electrodiagnostic localisation. [Read source](#)
3. British Orthopaedic Association. BOAST Peripheral Nerve Injury. December 2021. [Read source](#)
4. University of Arkansas for Medical Sciences. Anatomy Tables: Nerves of the Upper Limb. [Read source](#)
5. University of Arkansas for Medical Sciences. Anatomy Tables: Nerves of the Lower Limb. [Read source](#)
6. University of Arkansas for Medical Sciences. Topographical Anatomy of the Upper Limb. [Read source](#)
7. American Academy of Physical Medicine and Rehabilitation. Traumatic Lumbosacral Plexopathy. PM&R KnowledgeNow. [Read source](#)
8. Garozzo D, Zollino G, Ferraresi S. In lumbosacral plexus injuries can we identify indicators that predict spontaneous recovery or the need for surgical treatment? Results from a clinical study on 72 patients. J Brachial Plex Peripher Nerve Inj. 2014;9:1. doi:10.1186/1749-7221-9-1. [Read source](#)
9. Griffith JF, Guggenberger R. Peripheral Nerve Imaging. In: Musculoskeletal Diseases 2021–2024. Springer; 2021. Table 18.1. doi:10.1007/978-3-030-71281-5_18. [Read source](#)
10. Royal National Orthopaedic Hospital. Rehabilitation Following a Peripheral Nerve Injury (Brachial Plexus). Patient information guide. [Read source](#)
11. Royal National Orthopaedic Hospital. A Patient's Guide to the Brachial Plexus. [Read source](#)
12. Leeds Teaching Hospitals NHS Trust. Brachial Plexus Injuries: Your Condition and Treatment. [Read source](#)
13. Martin E, et al. Timing of surgery in traumatic brachial plexus injury: a systematic review. J Neurosurg. 2019;130:1333–1345. doi:10.3171/2018.1.JNS172068. [Read source](#)
14. Lang EM, Borges J, Carlstedt T. Surgical treatment of lumbosacral plexus injuries. J Neurosurg Spine. 2004;1:64–71. doi:10.3171/spi.2004.1.1.0064. [Read source](#)
15. Royal National Orthopaedic Hospital. Peripheral Nerve Injury Unit. Specialist service scope. [Read source](#)
16. National Institute for Health and Care Excellence. Rehabilitation after traumatic injury. NG211. 2022. Sections 1.2, 1.11, 1.13 and 1.16. [Read source](#)
17. University of Arkansas for Medical Sciences. Anatomy Tables: Nerves of the Pelvis and Perineum. [Read source](#)

Sources checked 13 October 2026.

Vascular Injuries in Major Trauma

CHAPTER 8

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

Vascular injuries deserve a separate chapter because they can determine the outcome of major trauma within minutes. They belong prominently under C, circulation, but their consequences extend throughout the patient: cerebral ischaemia, loss of an organ, loss of a limb and the systemic consequences of shock. My starting point is therefore to ask two questions together: where is blood being lost, and which tissues are no longer receiving it?

An obvious bleeding vessel commands attention. An artery injured inside its wall may initially attract very little. This is the particular danger of blunt trauma: stretching, compression and deceleration can damage a vessel without producing an external wound. The challenge is to recognise both the patient who needs immediate haemorrhage control and the patient whose apparently satisfactory circulation conceals an evolving injury.

This chapter considers adult vascular trauma within the multiply injured patient. Its emphasis is clinical judgement, recognition of common patterns, investigation and coordination of treatment. The detailed operative approach depends on the anatomical injury, available expertise and associated trauma.

Availability is part of treatment

Vascular expertise must be activated early when the mechanism, examination or physiology suggests serious vessel injury. In practice, a service needs more than a name on a rota. It needs a clinician who can attend promptly, a theatre that can receive the patient, blood products, appropriate imaging and a team capable of acting together. Resident and on-call arrangements vary; the practical question is whether the required skills reach the patient before preventable harm occurs.

I regard this as part of the philosophy of centralised major trauma care. The anaesthetist, trauma surgeon, vascular surgeon, orthopaedic surgeon, interventional radiologist and nursing team contribute different elements of one treatment. In a threatened limb, the sequence of their actions matters as much as their individual technical ability. Early discussion should settle who is leading, where the patient is going and what must happen first.

What has happened to the vessel

Vessels can fail by losing continuity, by losing patency, or by developing an abnormal communication. A partial wall injury may become more important over time. An initially patent artery can thrombose; a contained leak can enlarge; an arteriovenous fistula can remain unrecognised until swelling or a bruit develops.

Table 1 Patterns of vessel damage

Injury	What it means	Clinical consequence
Intimal tear	Damage to the inner lining, sometimes with an intimal flap	Flow may initially persist; thrombosis or embolisation may follow.
Dissection	Blood separates layers within the vessel wall	The true lumen can narrow or occlude without external bleeding.
Laceration or transection	Partial or complete disruption of the vessel	Haemorrhage, distal ischaemia, or both; local containment can hide blood loss.
Thrombosis or occlusion	Obstruction within an injured vessel	Threatened limb or organ despite little visible bleeding.
Pseudoaneurysm	A contained leak communicating with the arterial lumen	Delayed bleeding, expansion, compression or embolisation.
Arteriovenous fistula	Traumatic communication between an artery and vein	Abnormal flow, swelling, bruit or thrill; some present late.

Blunt mechanisms are central to this book, particularly collisions, falls and crush injuries. Penetrating injuries remain an important cause of vascular trauma and may damage adjacent nerves, veins and viscera along the same trajectory. The proportion of blunt and penetrating injuries varies between populations; we should not assume that the pattern of all major trauma is identical to the pattern of vascular trauma.

Read the physiology over time

The response to resuscitation helps determine whether there is time to investigate. The categories below describe a changing clinical state, not a permanent label. A patient may move rapidly from one category to another.

Table 2 Response to resuscitation

Response	Interpretation	Practical consequence
Sustained responder	Perfusion improves and remains satisfactory after initial resuscitation	Obtain appropriate imaging while continuing observation and looking for the source.
Transient responder	Improvement is followed by recurrent deterioration or continuing transfusion need	Suspect ongoing bleeding; prepare haemorrhage control. CT requires a senior decision that it can be performed safely and promptly.
Non-responder	No meaningful sustained improvement	Reassess for haemorrhage and other causes of shock; prioritise immediate intervention when uncontrolled bleeding is suspected.
In extremis	Peri-arrest or profound physiological collapse	Resuscitation and immediate life-saving intervention proceed together; routine diagnostic pathways are inappropriate.

NICE supports immediate CT in patients responding to resuscitation or with normal haemodynamics, while restricting imaging to what is needed to direct intervention in unstable non-responders. A negative FAST examination does not exclude abdominal or retroperitoneal bleeding. The decision is therefore about the patient's ability to tolerate the investigation, not merely the scanner's availability. [1]

One satisfactory blood pressure should not close the assessment. Review the trend in consciousness, skin perfusion, pulse, pressure, urine output, lactate or base deficit, and blood-product requirement. Repeated examination must also remain open to other explanations for deterioration, including thoracic obstruction or cardiac injury. A vascular diagnosis does not remove the need to reassess the whole patient.

Coagulation and resuscitation

Anatomical haemorrhage and traumatic coagulopathy must be treated together. Check haemoglobin, platelets, coagulation tests, fibrinogen, blood gas, temperature and ionised calcium, with repeated testing and viscoelastic assessment where available. An initially reassuring haemoglobin concentration does not reliably quantify acute blood loss. Ask about anticoagulants and antiplatelet drugs and arrange appropriate reversal when indicated. [2]

Activate the local major haemorrhage protocol when required. Use blood-product resuscitation with subsequent laboratory or viscoelastic guidance, maintain warmth, correct hypocalcaemia and avoid unnecessary crystalloid dilution. Give tranexamic acid promptly for significant traumatic bleeding or its risk, within three hours of injury according to the applicable protocol; it does not replace haemorrhage control. Blood-pressure targets must account for associated brain injury, where cerebral perfusion is a competing priority. [2]

The philosophical point is simple: a technically successful repair cannot compensate for a patient left cold, poorly perfused and coagulopathic. Resuscitation should make haemorrhage control possible, and haemorrhage control should allow resuscitation to succeed.

Examination and its limits

Expose and examine the injured region, document findings and compare with the opposite limb where appropriate. Record palpable pulses by name, temperature, colour, capillary refill, motor function and sensation. Repeat the assessment after realignment, reduction, splinting, intervention and transfer. The record should show when the examination occurred and what changed.

Pulsatile haemorrhage, an expanding haematoma, a bruit or thrill, and a significant pulse deficit are classic hard signs. Diminished or asymmetric pulses, a history of substantial bleeding, a stable haematoma and an adjacent neurological deficit are concerning even when less dramatic. These findings must be interpreted alongside the mechanism and overall perfusion. [3]

NICE specifically cautions against using capillary refill or a Doppler signal to exclude vascular injury. Persistent hard signs after necessary limb alignment or joint reduction require immediate surgical exploration; imaging must not delay revascularisation of a devascularised limb. [4]

The presence of some distal flow does not prove that the vessel wall is normal. Equally, a poor signal during profound shock does not identify the exact site of injury. We need an explanation that fits the mechanism, the limb and the patient. A finding that does not fit should prompt reassessment, not reassurance.

Doppler and the ankle brachial index

Handheld Doppler detects flow; duplex ultrasound combines anatomical imaging with flow assessment. They are different examinations. Duplex can help with accessible vessels and follow-up, but pain, swelling, wounds, dressings and the urgency of polytrauma may limit its practical value. A positive flow signal can coexist with an intimal injury.

The ankle-brachial index compares ankle and brachial systolic pressure. Older EAST guidance uses an ABI below 0.9, or an abnormal examination, to trigger further investigation in selected penetrating lower-limb injuries. That guidance should not be applied as a universal clearance rule in blunt polytrauma. [3]

There is a genuine difference between guidelines: ESVS 2025 advises against ABI for diagnosing or excluding extremity vascular trauma, favouring careful clinical examination and prompt CTA when significant injury cannot be excluded. [5] The practical lesson is to follow the agreed trauma pathway and never allow a reassuring pressure ratio to overrule unresolved clinical concern.

CT angiography must answer the question

When the patient can safely undergo imaging, CTA is central to identifying the vessel, the lesion and the tissues at risk. Arterial phase contrast timing, anatomical coverage and image quality matter; a routine scan does not automatically provide a diagnostic study of every artery.

ESVS recommends arterial and venous phase CTA as first-line investigation for suspected vascular trauma without clinical evidence of active bleeding. Patients too unstable for CTA should proceed immediately to operative intervention. Potential renal impairment alone should not postpone urgent CTA for a life- or limb-threatening injury in a haemodynamically stable patient. [5]

Ask a focused question of the study: is there leakage, wall injury, narrowing, occlusion or distal perfusion? Does the scan include the entire region of concern? If findings and examination disagree, speak directly to the radiologist and treating surgeon. A report is one part of the assessment; it cannot resolve an inadequately imaged vessel by declaring the rest of the scan satisfactory.

Common patterns across the body

The following patterns should guide suspicion rather than replace examination. Several can coexist in one patient.

Neck and cerebral circulation

Blunt carotid or vertebral injury can follow neck loading and associated cervical spine or craniofacial trauma. Dissection and thrombosis may produce cerebral ischaemia after an initially symptom-free interval. A new focal deficit, or a neurological finding inadequately explained by the brain scan, should reopen the vascular assessment.

EAST recommends a screening protocol for blunt cerebrovascular injury, with CTA for high-risk cervical injuries and consideration in lower-risk cervical injuries. Confirmed injury generally calls for antithrombotic treatment as early as safely possible, agreed with the teams managing intracranial or other bleeding. Routine stenting of grade II or III blunt cerebrovascular injuries is not recommended. Surveillance and treatment must be individualised. [6]

Penetrating neck injury adds the immediate threats of haemorrhage and an expanding haematoma compromising the airway. Airway and vascular planning therefore need to occur together. A difficult anatomical location should trigger early expert involvement, not repeated uncontrolled attempts at local haemostasis.

Thoracic aorta and shoulder girdle

Sudden deceleration can injure the thoracic aorta, often near the isthmus. Survivors may have a contained injury rather than free rupture. Contrast CT is the principal diagnostic investigation. When repair is indicated, endovascular treatment is generally favoured where anatomy and expertise permit. Selected

stable patients may undergo delayed repair while other injuries are managed; suspected rupture or instability demands urgent action. Blood-pressure control is appropriate only in the context of adequate perfusion and competing injuries. [7]

Around the shoulder, subclavian and axillary vessels may be injured by displacement, traction or penetrating trauma. Associated brachial plexus injury can dominate the presentation. Examine the circulation and nerve function separately: a neurological explanation for a weak arm does not establish that its blood supply is intact. The clavicle and surrounding structures can also make proximal access difficult.

Abdomen and renal vessels

Abdominal vascular trauma may present as concealed haemorrhage, visceral ischaemia, or both. Consider the aorta, inferior vena cava, iliac vessels and the arterial and venous supply to individual organs. The location of a haematoma matters, but opening a contained haematoma without an agreed means of control may remove the tamponade on which the patient depends.

The renal pedicle is vulnerable to deceleration, including intimal disruption and thrombosis. Haematuria may be absent despite important vascular injury. Contrast CT in a sufficiently stable patient evaluates perfusion and associated damage; selective embolisation can control suitable arterial bleeding. Main-vessel occlusion, pedicle disruption and bilateral injury require urgent specialist decisions that account for perfusion time, renal function and the other kidney. [8]

Mesenteric injury can interrupt bowel perfusion as well as cause bleeding. A satisfactory blood pressure does not establish bowel viability. These injuries belong in a shared discussion with the abdominal trauma surgeon, especially where reconstruction, resection or later reassessment may be required.

Pelvis

Pelvic haemorrhage can arise from venous plexuses, fractured bone and arterial injury. Pelvic stabilisation, packing and embolisation address different components of that problem. A binder or stabilised ring does not establish that arterial bleeding has stopped, and arterial embolisation does not correct every source of pelvic blood loss. The sequence depends on physiology and rapid local access to treatment. [9]

Injury to the common or external iliac artery may also threaten a lower limb. In a patient with pelvic disruption, distal limb examination must remain part of the assessment rather than being postponed until attention turns away from the pelvis.

Upper and lower limbs

Fractures, dislocations, crush injuries and penetrating wounds can injure an adjacent artery. Useful anatomical associations include the axillary artery at the shoulder, brachial artery at the elbow, femoral vessels in the thigh and popliteal artery around the knee. The examination must include the hand or foot beyond the visibly injured segment.

Knee dislocation deserves particular vigilance, including when the joint has reduced before arrival. The important question is what happened at the time of injury. Original clinical studies support structured examination and selective imaging in defined populations, but also show the limitations of relying on an isolated finding. Serial assessment remains essential when immediate imaging or exploration is not undertaken. [10]

Control haemorrhage and restore perfusion

Proximal control is fundamental to operative management of a bleeding vessel. The team must anticipate the source of inflow, the possibility of distal back-bleeding and the consequences of opening the injured region. Temporary control creates the opportunity to assess and repair; it is not the end of treatment.

For external limb haemorrhage, immediate pressure, appropriate packing or a tourniquet may be required. Blind clamping should be avoided. Record tourniquet application time and communicate it during every handover. An unstable patient with uncontrolled bleeding needs resuscitation and surgical intervention together. [11]

Definitive treatment may involve repair, an interposition graft, bypass, or selected endovascular treatment according to anatomy and purpose. [5] Selected non-occlusive lesions may be observed within a documented specialist plan. [3] The aim is appropriate haemostasis and perfusion with a repair the patient and injured tissues can tolerate. Observation means continuing responsibility for reassessment and follow-up.

Major venous injury must not be underestimated. It may cause profound blood loss and, in a limb, impair outflow after arterial flow is restored. Repair or ligation requires judgement about physiology, accessibility and the consequences of venous obstruction. Arterial patency alone is not a complete assessment of circulation.

REBOA should not be presented as a routine solution to torso haemorrhage. The UK randomised trial found no mortality benefit from the emergency-department REBOA strategy and a probability of harm. Any exceptional use requires an established specialist pathway and immediate definitive haemorrhage control. [12]

The threatened limb and the order of reconstruction

For arterial injury associated with musculoskeletal trauma, the June 2026 BOAST emphasises that there is no safe ischaemic interval and that emergency revascularisation should commence within one hour of hospital arrival. That is a service standard, not permission to wait or a guarantee of salvage. [11]

BOAST recommends temporary shunting to restore flow rapidly, followed by skeletal reduction and stabilisation before definitive revascularisation. This addresses the practical conflict between a limb needing blood now and a repair needing a stable skeleton. The general ESVS guidance also supports immediate definitive repair where it is feasible without harmful delay, using a shunt when it is not. [5,11]

The decision should be made jointly and communicated clearly. What is the shortest route to reperfusion? Will fixation delay it? Will an unstable fracture threaten the repair? How will the graft be protected and covered? These questions are more useful than a rigid rule divorced from the injury.

Reconstruction must also consider muscle viability, nerve damage, contamination, soft-tissue loss and the patient's overall condition. A technically patent vessel does not guarantee a useful limb. Decisions about amputation should include the patient when possible and appropriate senior multidisciplinary judgement, with the reasoning documented.

Reperfusion and compartment syndrome

Restoring flow can be followed by swelling and compartment syndrome. Crush injury, prolonged ischaemia and combined arterial and venous injury increase concern. Observational data associate earlier fasciotomy in selected vascular injury patients with better limb outcomes, but cannot establish a universal timing rule

for every injury. [13] Reperfusion also requires systemic monitoring for metabolic disturbance, rhabdomyolysis and renal dysfunction. [15]

Repeated assessment must include pain, pain with passive stretch, compartment tension, neurological findings and analgesic requirement. A palpable pulse does not exclude compartment syndrome. In an unconscious or otherwise unassessable patient, clinical silence is not reassurance; pressure measurement may be needed. Confirmed acute compartment syndrome requires immediate decompression. BOAST recommends hourly documented assessment in patients at risk. [14]

Fasciotomy must always be considered after revascularisation in musculoskeletal arterial trauma; a decision against it should be documented by the senior decision maker. [11] Follow-up must include the wounds and the functional limb, as well as the repaired vessel.

Continuing responsibility

The handover should specify the injured vessel, the lesion, treatment performed, remaining uncertainty, limb and neurological findings, tourniquet or ischaemia times where known, and the agreed surveillance plan. It should identify who must be called if perfusion changes. A further examination after transfer provides the receiving team with its own baseline.

Longer-term review should address recurrent ischaemia, delayed swelling or bleeding, graft or stent surveillance where appropriate, wound healing, nerve recovery and rehabilitation. Antithrombotic treatment and venous thromboembolism prevention need explicit decisions that take account of competing bleeding risks. The patient should understand which symptoms require urgent reassessment and which team owns follow-up.

For me, the central lesson is that vascular care is continuous. It begins with suspicion, develops through repeated examination and physiological assessment, and continues after the immediate threat has passed. The patient who is bleeding needs control without avoidable delay. The patient with a hidden vessel injury needs us to keep questioning an incomplete explanation. Both depend on a team that recognises when the next decision has become urgent.

References

Guidance and source versions checked 13 October 2026. Numbered references support the associated clinical points; the narrative emphasis on judgement and coordination reflects the author's chapter philosophy.

1. National Institute for Health and Care Excellence. Major trauma assessment and initial management. NG39. 2016. Recommendations on haemorrhage and imaging. [Source link](#)
2. Rossaint R, Afshari A, Bouillon B, et al. The European guideline on management of major bleeding and coagulopathy following trauma sixth edition. Critical Care. 2023;27:80. [DOI link](#)
3. Eastern Association for the Surgery of Trauma. Penetrating lower extremity arterial trauma evaluation and management. 2012. [Source link](#)
4. National Institute for Health and Care Excellence. Fractures complex assessment and management. NG37. Recommendations 1.2.1–1.2.5. [Source link](#)
5. Wahlgren CM, Aylwin C, Davenport RA, et al. European Society for Vascular Surgery 2025 clinical practice guidelines on the management of vascular trauma. European Journal of Vascular and Endovascular Surgery. 2025;69:179–237. Recommendations 9–14 and 82–84. [DOI link](#)
6. Eastern Association for the Surgery of Trauma. Blunt cerebrovascular injury evaluation and management. 2020. [Source link](#)
7. Eastern Association for the Surgery of Trauma. Blunt aortic injury evaluation and management. 2015. [Source link](#)
8. Coccolini F, Moore EE, Kluger Y, et al. Kidney and uro-trauma WSES-AAST guidelines. World Journal of Emergency Surgery. 2019;14:54. [DOI link](#)
9. Coccolini F, Stahel PF, Montori G, et al. Pelvic trauma WSES classification and guidelines. World Journal of Emergency Surgery. 2017;12:5. [DOI link](#)
10. Weinberg DS, Scarcella NR, Napora JK, Vallier HA. Can vascular injury be appropriately assessed with physical examination after knee dislocation? Clinical Orthopaedics and Related Research. 2016;474:1453–1458. [DOI link](#)
11. British Orthopaedic Association, BAPRAS and Vascular Society. Diagnosis and management of arterial injuries associated with musculoskeletal trauma. BOAST. Updated June 2026. [Source link](#)
12. Jansen JO, Hudson J, Cochran C, 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;330:1862–1871. [DOI link](#)
13. Farber A, Tan TW, Hamburg NM, et al. Early fasciotomy in patients with extremity vascular injury is associated with decreased risk of adverse limb outcomes a review of the National Trauma Data Bank. Injury. 2012;43:1486–1491. [Source link](#)
14. British Orthopaedic Association. Diagnosis and management of compartment syndrome of the extremities. BOAST. Updated July 2025. [Source link](#)
15. Kodadek L, Carmichael SP II, Seshadri A, et al. Rhabdomyolysis an American Association for the Surgery of Trauma Critical Care Committee clinical consensus document. Trauma Surgery and Acute Care Open. 2022;7:e000836. [DOI link](#)

CHAPTER 9

Extremity Injuries

A limb injury may be the most visible part of major trauma. Deformity, an open wound or exposed bone naturally attracts attention. The task is to recognise its importance without losing the rest of the patient. A threatened limb can demand immediate action, while a technically complex reconstruction may need to wait until circulation, breathing and temperature have recovered.

The arms and legs are mobile structures, often exposed to direct impact, traction, twisting and penetration. Skin, muscle, vessels, nerves, tendons, ligaments, cartilage and bone can be injured together. The radiograph shows only part of that event. My concern is what happened to the whole limb, how that injury affects the whole patient and what function we can preserve.

The soft tissues tell part of the story

A closed fracture has no communication between the fracture and the external environment through a wound. An open fracture does. The opening may be small, remote from the most obvious fracture level or produced by a fragment emerging through the skin. Bone need not be visible for the fracture to be open.

The distinction between an inside-out puncture and an outside-in crush is useful when reconstructing the mechanism. It does not, by itself, assign a Gustilo-Anderson grade. Energy, contamination, tissue loss, periosteal stripping and arterial injury matter. A small wound can conceal an extensive zone of damage. [1]

An intact skin surface can also be misleading. A closed injury may include major muscle contusion, degloving, vascular disruption or evolving compartment syndrome. Repeated examination should therefore ask whether the skin remains viable, whether swelling is increasing and whether the neurological or circulatory findings have changed.

Assessment that can be repeated

Record the mechanism, injury time, wounds, deformity, skin condition, distal perfusion and named motor and sensory findings. Document what cannot be tested. Repeat the examination after reduction, splinting, transfer and surgery. The next clinician needs a comparison, not simply the words neurovascularly intact. [2,3]

Inspect the joint above and below a fracture and the remaining limb. Complete the secondary and tertiary surveys when safe. An injured hand or foot can be overlooked while larger injuries dominate the first hours. The patient who later cannot use a walking aid or bear weight may be revealing an injury that was never adequately assessed.

Classification should describe the injury

Tscherne and Oestern developed a classification of soft-tissue injury in both open and closed fractures. For closed injuries, grades 0 to 3 describe increasing damage: from little or no injury, through superficial abrasion or contusion, to deep tissue damage and extensive crushing or degloving. It is a language for describing soft tissues, not a test that excludes compartment syndrome. [4]

Gustilo-Anderson grading should be reassessed after operative exploration and wound excision reveal the injury zone. The simplified descriptions below support communication; the operative record should describe the actual structures, contamination and tissue loss. [1,5]

Open fracture grade	Simplified description
I	Small, relatively clean wound with limited soft-tissue damage.
II	Larger wound without the extensive damage characteristic of type III.
IIIA	Severe injury, but adequate viable soft-tissue coverage of bone remains.
IIIB	Extensive soft-tissue loss and periosteal stripping, with exposed bone requiring reconstructive coverage.
IIIC	Arterial injury requiring repair to maintain limb viability, whatever the wound size.

Table 9.1 Gustilo-Anderson classification in clinical context. The type III subdivision was described by Gustilo, Mendoza and Williams. Wound length alone is insufficient. [1,5]

Ask what must happen first

The first decision is the immediate purpose of treatment. Is the limb bleeding? Is it ischaemic? Is a dislocation stretching the skin, nerve or vessel? Is there compartment syndrome or gross contamination? These questions have priority over choosing the final implant.

A patient can need urgent limb treatment despite being too unstable for definitive fracture reconstruction. Conversely, a resuscitated patient may be suitable for definitive treatment without an unnecessary period of temporary fixation. The reasoning described in Chapter 1 applies to each operation and should be reconsidered as the physiological course changes.

Early care of the open fracture

For open long-bone, hindfoot and midfoot fractures, activate the orthoplastic pathway. Give intravenous prophylactic antibiotics promptly, ideally within one hour of injury, under the network antibiotic policy. Record administration and address tetanus protection. Carefully realign and splint the limb. Remove gross surface contamination, document the wound appropriately and cover it with saline-moistened gauze and an occlusive dressing. Repeated emergency-department washouts add handling without replacing formal wound excision. [2]

BOAST specifies immediate debridement for highly contaminated wounds or vascular compromise, within 12 hours for other solitary high-energy open fractures, and within 24 hours for lower-energy injuries. These are service standards, not permission to delay a deteriorating patient. Orthopaedic and plastic surgeons should plan debridement, skeletal fixation and coverage together. Definitive closure or coverage should be achieved within 72 hours if not possible at the initial operation. [2]

The first operation needs a clear account of skin, muscle, tendon, nerve, vessel and bone injury. A wound that looks smaller after suturing has not necessarily become biologically safer. The important endpoint is an adequately treated injury with viable tissues and a coherent reconstructive plan.

Stability and coverage belong in one plan

The choice of external or internal fixation depends on physiology, fracture pattern, contamination, the soft-tissue envelope and the next operation. Temporary fixation should preserve alignment while leaving useful access for later reconstruction. The position of pins, bars and incisions has consequences for flap design, nursing and the definitive construct.

NICE recommends coordinated wound excision, fixation and definitive cover. When definitive internal fixation is selected for an open fracture, soft-tissue cover should take place at the same time. An interim dressing protects the wound while treatment is organised; it does not remove the need for timely coverage. The exact combination depends on the injury and the resources of the treating orthoplastic service. [6]

This is a practical example of why centralisation matters. Expertise in fixation and expertise in tissue coverage need to meet before the patient has accumulated avoidable procedures. The team should be able to explain why an operation is definitive, why it is staged, and what must happen before the next stage.

The limb with vascular compromise

Haemorrhage control and restoration of perfusion are related but different objectives. A tourniquet may control life-threatening external bleeding while creating an obligation to record the application time and arrange prompt definitive care. Blind clamping can injure neighbouring structures and should be avoided. [3]

Urgently realign and splint a pulseless, deformed limb, then reassess. Persistent ischaemia requires emergency consultant-led treatment. CT angiography is useful when it can define the lesion without delaying necessary reperfusion. A Doppler signal or reassuring capillary refill must not close the assessment when arterial injury remains possible. [3,6]

The June 2026 BOAST treats revascularisation as an emergency and specifies commencement within one hour of hospital arrival. Temporary shunting may rapidly restore flow, allowing prompt skeletal stabilisation before definitive vascular reconstruction. The sequence must be agreed by the treating teams. There is no period of ischaemia that can safely be treated as spare time. Consider fasciotomy after revascularisation and record the senior decision. [3]

Compartment syndrome requires active surveillance

Rising pressure within a closed muscle compartment threatens tissue perfusion. Pain disproportionate to the apparent injury and pain on passive stretch are important findings, but reduced consciousness, neurological injury and analgesia may complicate interpretation. A palpable pulse does not exclude compartment syndrome.

The 2025 BOAST recommends hourly documented assessment in patients at risk. Where findings are inconclusive or examination is incomplete, senior review and pressure monitoring should be considered, with concurrent blood-pressure measurement. Release constricting circumferential dressings and reassess promptly while arranging definitive assessment. Once the diagnosis is made, immediate surgical decompression is required. [7]

A diastolic-minus-compartment pressure difference below 30 mmHg indicates increased risk; an absolute pressure above 40 mmHg is another reason to consider urgent decompression. These values require consultant interpretation with the clinical course. Pressure measurement must not delay treatment of an established clinical diagnosis. Decompress all involved compartments and document tissue viability and the subsequent wound plan. [7]

An open fracture does not reliably decompress every compartment. Reperfusion can also change the risk after an initially ischaemic limb has been restored. Surveillance therefore continues through the operation and handover; the fact that the patient has already reached theatre does not finish the assessment.

Nerves, joints and the apparently smaller injury

A neurological deficit should be localised and described rather than labelled automatically as neurapraxia. Record individual movements, sensory territories and the effect of pain or sedation. Associated dislocation, vascular injury, compression or an open nerve wound changes urgency. Chapter 7 develops the distinction between root, plexus and peripheral-nerve injury.

The BOAST peripheral-nerve standard requires early specialist advice for defined patterns, including advice before planned internal fixation of a fracture associated with nerve injury. A newly identified intraoperative injury or persistent new postoperative deficit needs immediate specialist discussion. Observation should include a named service, serial assessment and a review date. [8]

Joint injury can affect recovery even when the shaft fracture receives most of the early attention. An open joint, unstable dislocation, tendon disruption or threatened skin requires its own plan. After reduction, confirm the result, reassess circulation and neurology, and investigate residual incongruity or instability. Avoid forcing a joint through painful movement merely to complete a checklist.

Hands provide grip and support for transfers; feet provide the contact through which walking becomes possible. Their assessment has to fit within safe movement limits, but it must not disappear from the major-trauma record. A satisfactory whole-body CT does not establish that every small bone, tendon or ligament has been examined.

Reconstruction or amputation

The objective is a surviving person with the best attainable function. Sometimes this requires limb salvage; sometimes amputation is the appropriate treatment. A limb that can technically be retained may still impose repeated operations, prolonged dependence and uncertain useful function. The discussion should make those burdens visible without assuming that disability makes a life less valuable.

NICE advises against using an injury-severity score alone to decide salvage or amputation. Emergency amputation may be required for uncontrollable life-threatening bleeding, unacceptable risk to life from attempted salvage, or an unsalvageable limb after specialist assessment. Other decisions require multidisciplinary input, including reconstruction and rehabilitation expertise, with the patient and family or carers involved where possible. [6]

An early sensory deficit should be interpreted in its anatomical and clinical context. It is not a substitute for the whole decision. Where time allows, explain expected operations, likely restrictions, pain, prosthetic or orthotic options and the uncertainty of each route. The patient should understand which questions are known and which remain open.

The first operation should help the next stage

Restoring length, alignment and useful stability can make nursing and rehabilitation possible. It can also impose blood loss, operative time and a physiological burden. The team should agree what benefit is needed now and what deterioration would change the plan. A technically achievable reconstruction is not automatically the best first operation.

Persistent drainage, wound breakdown, new neurological loss, increasing pain or failure to progress requires a fresh explanation. Follow-up must distinguish normal uncertainty from evidence of infection, mechanical failure, nonunion, vascular compromise or another remediable problem. The original treatment plan remains a hypothesis that the patient's recovery can challenge.

Write instructions that permit rehabilitation

Record weight-bearing status separately for each affected limb. BOAST uses non-weightbearing, limited weightbearing and unrestricted weightbearing. Restrictions should state the clinical reason, functional limits, duration, aids and review plan. Ambiguous labels or percentages of body weight are poor substitutes for instructions the patient can use. [9]

Ask how those instructions work together. A patient with an injured shoulder and a protected lower limb may be unable to use crutches. A patient with bilateral injury may need a different transfer plan. Physiotherapy, occupational therapy, nursing and the surgical teams should resolve these problems before they become barriers to discharge.

The rehabilitation plan should address symptoms, function and the person's environment. NICE recommends coordinated assessment and goals agreed with the patient. The same injury may have different consequences for someone who climbs for work, cares for a relative or lives above several flights of stairs. Those circumstances belong in the clinical conversation. [10]

The philosophy of limb care

For me, the guiding question is what this treatment will allow the person to do. Bone union, soft-tissue survival and restored blood flow are necessary achievements, but the patient lives with their combined result. Pain, sensation, joint movement, strength and confidence determine whether that result becomes useful.

Good extremity care therefore begins with the whole patient and continues with the whole limb. It combines urgent treatment of time-critical threats with attention to tissue biology and realistic functional goals. Rehabilitation is the next expression of the same responsibility, and it is the subject of the final chapter.

References

1. AO Foundation. Principles of management of open fractures. AO Surgery Reference. Classification and soft-tissue assessment. [Read source](#)
2. British Orthopaedic Association. BOAST Open Fractures. December 2017. [Read source](#)
3. British Orthopaedic Association, BAPRAS and Vascular Society. Diagnosis and management of arterial injuries associated with musculoskeletal trauma. June 2026. [Read source](#)
4. Tscherne H, Oestern HJ. A new classification of soft-tissue damage in open and closed fractures. Unfallheilkunde. 1982;85:111-115. [Read source](#)
5. Gustilo RB, Mendoza RM, Williams DN. Problems in the management of type III severe open fractures. A new classification of type III open fractures. J Trauma. 1984;24:742-746. [Read source](#)
6. National Institute for Health and Care Excellence. Fractures complex assessment and management. NG37. Recommendations. [Read source](#)
7. British Orthopaedic Association. Diagnosis and Management of Compartment Syndrome of the Extremities. Updated July 2025. [Read source](#)
8. British Orthopaedic Association. BOAST Peripheral Nerve Injury. December 2021. [Read source](#)
9. British Orthopaedic Association. Mobilisation and weightbearing after orthopaedic surgery or musculoskeletal injury. August 2024. [Read source](#)
10. National Institute for Health and Care Excellence. Rehabilitation after traumatic injury. NG211. 2022. [Read source](#)

Chapter developed from the author's available dictation and completed for this edition. Clinical sources reviewed 13 October 2026. The chapter explains professional decision-making; it is not a procedural manual.

CHAPTER 10

Functional Return Following Major Trauma

Rehabilitation and return to everyday life

Mr Peyman Bakhshayesh, MD, PhD, MBA

Consultant Trauma and Orthopaedic Surgeon

Clinical Lead for General Trauma, Leeds Teaching Hospitals NHS Trust

Honorary Clinical Senior Lecturer, University of Leeds

The responsibility that follows survival

Major trauma can change the direction of a person's life in a few seconds. The immediate injuries demand resuscitation, surgery and intensive nursing care, but their consequences extend beyond the hospital admission. A person who previously worked, cared for a family and moved freely through the community may face a prolonged period of dependence. Some recover much of their previous function; others live with lasting disability. Our responsibility must include both possibilities.

Throughout this book, I have argued that the injured person must be understood as a whole. The energy transferred during trauma may damage several organs, and the effect of those injuries cannot be understood by considering each operation separately. In rehabilitation, this becomes particularly clear. A repaired lower limb may be ready for mobilisation while an injured upper limb prevents the use of walking aids. A satisfactory radiograph may coexist with disabling fatigue, fear or pain. The next useful treatment depends on how these problems interact.

I regard functional return as the final purpose of major trauma care. We should ask what the person needs to regain control over daily life, sustain relationships and participate in activities they value. That question belongs in the first admission and should remain visible through reconstruction, rehabilitation and community follow-up.

This closing chapter considers adult rehabilitation after major trauma, with particular attention to mental health, home circumstances, employment and the organisation of continuing care. Specialist brain injury, spinal cord injury, nerve injury and amputation pathways remain essential where indicated. The principles described here support individual clinical assessment and shared decisions.

What functional return means

Rehabilitation seeks to improve functioning within the person's actual environment. The World Health Organization places everyday activities, participation and the interaction between health and environment at the centre of this approach. A disability therefore cannot be described adequately by an anatomical diagnosis alone. [1,2]

Consider two people with similar mobility limitations. One can enter an accessible home, reach a bathroom and travel to work. The other faces stairs, unsuitable transport and a job requiring prolonged standing. Their injuries may be comparable, but the practical consequences are different. Changing the environment can be as important to independence as improving strength or range of movement.

We should also distinguish returning to an activity from sustaining it. Walking across a therapy room does not establish that a person can manage a shopping trip. Completing one shift does not establish that the following week will be manageable. Useful assessment asks about effort, symptoms afterwards, the help required and whether the activity can be repeated safely.

The patient's own priorities give these assessments meaning. Being able to wash without assistance, take a child to school, resume study or visit friends may matter more than a small change in a clinical score. Goals should be ambitious enough to offer direction and realistic enough to guide the next step. When recovery changes, the goals can change without implying failure.

Rehabilitation begins during acute care

Early rehabilitation requires physiotherapy and occupational therapy to contribute alongside medical and nursing care. NICE recommends a coordinated assessment, an individual rehabilitation plan and review of agreed goals. Rehabilitation should begin as soon as clinically appropriate, with the intensity and content adapted to the person's condition. [3]

For patients who have required critical care, weakness and reduced endurance may be accompanied by cognitive and psychological difficulties. Assessment should address physical and non-physical morbidity, nutrition and the person's capacity to participate. Information and rehabilitation plans must follow the patient when they leave critical care. [4]

Early does not mean forcing activity through instability or ignoring a surgical reconstruction. The team needs explicit instructions about weight-bearing, joint movement, wound protection and any neurological or vascular precautions. Restrictions should identify the relevant limb or structure, the permitted activity and the point at which the instruction will be reviewed. An unexplained instruction to remain non-weight-bearing is an incomplete rehabilitation plan.

As a surgeon, I believe we should make the functional consequences of our decisions visible. If several limbs are injured, how will the patient transfer? If further surgery is planned, what can be achieved safely in the interval? If immobilisation is necessary, how will we protect the rest of the person's function? These questions belong in the discussion of treatment, alongside fixation and tissue healing.

Rehabilitation medicine can help integrate competing restrictions and complex needs. Physiotherapy develops movement and physical capacity. Occupational therapy examines how the person performs daily activities and what adaptation or equipment would help. Rehabilitation nursing carries agreed approaches into everyday care. Speech and language therapy, dietetics, psychology, prosthetics and orthotics contribute according to need. These disciplines form part of the broader rehabilitation workforce described by WHO. [1]

Shared goals and clear responsibility

Centralisation brings specialist expertise together, but the benefit can be lost when the patient moves between services. A person should not have to reconcile contradictory instructions or explain the entire admission repeatedly. NICE supports a shared rehabilitation plan, coordinated handover and early discharge planning. [3]

My practical expectation is that each important goal has a named person or service responsible for moving it forward. A referral is the beginning of a handover. The team should know whether it has been accepted and

what happens while the patient waits. The following questions can keep multidisciplinary discussions connected to the patient's daily life.

Table 1 Questions for a coordinated rehabilitation review

Area	Question to resolve
Physical recovery	What is safe now, and which restriction needs review?
Daily activities	What can the person do independently and where is help still required?
Mental health and cognition	What affects understanding, distress, safety or engagement?
Home and family	Will the proposed arrangements work in this household?
Work or education	What demands must be assessed before a sustainable return?
Continuity	Who owns the next action and who can the patient contact?

Mental health is health

Mental health is part of trauma care. A psychiatric diagnosis must never reduce the seriousness with which physical symptoms are assessed, the effort devoted to reconstruction or the opportunity offered for rehabilitation. The same principle applies when an injury follows self-harm. Treatment is not conditional on whether staff understand or approve of the circumstances.

A major trauma admission may bring previously unrecognised mental health needs to attention. Other patients develop distress during recovery, or experience a recurrence of an existing illness. We should avoid assuming that every person who is frightened, withdrawn or angry has the same problem. Pain, sleep disruption, delirium, brain injury, medication effects and difficulty communicating may all require consideration before behaviour is interpreted.

Compassion requires practical changes as well as respectful language. A person with a learning disability, sensory impairment or communication difficulty may need accessible explanations, additional time, an interpreter or support from someone who knows them well. Participation improves when the service adapts its communication. These principles are consistent with NICE guidance on patient experience. [5]

Psychologists and psychiatrists have complementary roles. Psychological assessment can help the team understand distress, adjustment and barriers to rehabilitation. Liaison psychiatry is especially important when there is serious mental illness, diagnostic uncertainty or concern about self-harm. Patients and families should understand why a referral is offered; it should not be presented as punishment for difficult behaviour.

After self-harm, psychosocial assessment should proceed alongside physical treatment as soon as the person can participate. NICE advises against waiting until medical treatment is complete and against using risk scores or broad risk categories to decide treatment or discharge. Assessment should identify the person's needs, circumstances and immediate safety concerns, with a collaborative care and safety plan. [6]

Psychological treatment must fit the identified problem. For adults with clinically important post-traumatic stress symptoms or PTSD, NICE recommends trauma-focused therapies, including trauma-focused cognitive

behavioural therapy; EMDR is another recommended option in appropriate circumstances. Routine psychologically focused debriefing is not recommended. A person should not be compelled to recount the event as a condition of receiving support. [7]

My concern is that a patient labelled uncooperative may stop receiving opportunities to recover. Before accepting that label, we should ask what the person has understood, what they fear, whether symptoms are controlled and whether the proposed activity is achievable. Mental illness is not evidence of weakness. Nor should learning disability, body size or an injury mechanism be used as a shortcut for judging motivation or future behaviour.

Our published Swedish study of high-energy pelvic injuries found an association between intentional falls from height and mortality during the first year after injury. That finding concerns a specific cohort and outcome. This finding does not determine an individual patient's rehabilitation potential, which must be assessed on its own merits. For me, it reinforces the need for physical and mental healthcare to work together. [8]

Pain and the pace of recovery

Persistent pain can limit activity and confidence long after the emergency has passed. In the Victorian longitudinal study led by Gabbe, half of respondents at three years reported pain or discomfort on the EQ-5D questionnaire. This describes a substantial continuing burden, although it does not specify the cause of pain in each person. [9]

I would not regard continuing pain as adequately assessed simply because a fracture has united. The clinical question remains whether there is a remediable problem, a neuropathic component, a mechanical limitation or a need for specialist pain rehabilitation. The management plan should explain what has been considered and how progress will be judged.

Pain treatment and functional goals should be discussed together. The aim may initially be to tolerate dressing, sleep more consistently or take part in a short therapy session. Progress does not have to mean complete symptom resolution. Equally, a sudden deterioration or a new symptom should prompt reassessment rather than an automatic instruction to persevere.

Recovery often changes pace. Further surgery, a setback at home or loss of confidence may require the plan to be revised. We should explain uncertainty honestly and maintain access to review. A person who needs a different route through rehabilitation has not failed the original plan.

Returning home and supporting the household

Going home is a major transition. The patient leaves an environment where help is close and enters one where small practical obstacles can determine the whole day. Home adjustment must therefore be considered before discharge, with the patient, family or carers, occupational therapy and relevant community services. Equipment, support and follow-up should be arranged around the assessed needs. [3]

A discharge destination should be tested against ordinary activities. Can the person enter the property, get to the toilet at night, prepare food and obtain medicines? Can they use the equipment in the available space? Who will help when the person who usually provides support is at work? An address in the notes is not an answer to these questions.

Families need to be partners in planning, with the patient's agreement. They also need an honest discussion about what they can sustain. We should not assume that a relative can provide unlimited care, lift safely or

give up employment. The impact on children and other dependants deserves attention, as does the possibility that the injured person was previously the main carer.

Social workers, housing teams, community rehabilitation and relevant public agencies may need to coordinate their contributions. Where adaptations or support are delayed, I favour an explicit interim plan with a named contact and a review date. Responsibility should remain visible while the patient moves through administrative processes.

Returning to society also includes privacy, intimacy, cultural life and companionship. These subjects can be difficult to raise on a busy ward, but they may become central once immediate survival is secure. The patient should have a private opportunity to explain what matters and be directed to appropriate expertise.

Work education and financial recovery

A previous job may no longer match the person's physical or cognitive capacity. This can threaten income, identity and confidence at the same time. We should introduce the possibility of vocational rehabilitation early, without making promises about dates or implying that paid employment determines the value of recovery.

Occupational therapy and occupational health are different but complementary. Occupational therapy addresses meaningful activity and daily function. Occupational health helps assess work demands and suitable workplace arrangements. With the person's agreement, discussion with the employer can address phased hours, modified duties, equipment and review points. NICE guidance on long-term sickness absence emphasises agreed adjustments and sustainable return. [10]

The work itself must be understood. A job title rarely explains the need to climb, lift, drive, concentrate, make safety-critical decisions or cope with an unpredictable shift. Travel to work and recovery afterwards also affect feasibility. Where the previous role remains unsuitable, retraining, further education or a different role may offer a realistic route forward.

Return should be assessed over time. Collie, Gabbe and colleagues followed 1,086 people who had been working or in full-time education before major trauma. Over four years, the study identified early sustained, delayed, failed and absent return. This supports asking whether participation lasts, rather than recording only the first day back. The findings describe groups and should not be used as an individual forecast. [11]

Financial support deserves a place in clinical planning because financial insecurity can make practical recovery harder. Patients may need independent advice about benefits, employment arrangements, insurance or compensation. Advice should be tailored to their circumstances and jurisdiction. People who were retired, unemployed or providing unpaid care before injury need equally serious attention to their goals.

Day One and support from lived experience

At Leeds General Infirmary, Day One Trauma Support offers an important example of support extending beyond the immediate treatment of injuries. Professor Peter Giannoudis and former patients established Day One in 2014. It became an independent national charity in May 2021. Its development reflects the recognition that patients and families need practical and emotional help while rebuilding their lives. [12]

Day One describes support including small grants, benefits and welfare advice, legal support, counselling and contact with peers who have experienced major trauma. These services address concerns that may be difficult

to resolve within a surgical consultation. Availability and individual arrangements should be checked with the charity. [13]

I regard the contribution of charities and people with lived experience as an essential part of a humane trauma community. A peer supporter may help someone formulate a question they have not yet found words for. Families may find reassurance in speaking to others who understand the uncertainty of recovery. Such relationships should respect the person's preferences and readiness.

Charitable support should strengthen a properly funded rehabilitation system. Patients should receive clinical care and necessary social support according to need, with voluntary organisations contributing their particular expertise. Fundraising and public awareness can also help society understand why the consequences of trauma continue after discharge.

What long term research tells us

Professor Belinda Gabbe and colleagues in Australia have made a substantial contribution by following patients beyond the acute admission. Their study of severe pelvic ring fractures is particularly relevant to orthopaedic trauma. Of 114 eligible survivors, 111 participated in follow-up. At 24 months, 78 of 101 assessed participants were living independently; among previously employed participants with work data at that point, 40 of 68 had returned to work. These are different outcomes with different denominators. [14]

Those findings demonstrate both the possibility of improvement and the extent of continuing need. They do not mean that every person with a similar fracture has the same prognosis. The study concerned selected severe pelvic injuries treated at two Australian major trauma centres; associated injuries, complications and social circumstances influence interpretation.

The wider Victorian study of long-term health found persistent difficulties with mobility, daily activities, pain and emotional health at three years. Its anxiety and depression measure recorded questionnaire-reported problems, not confirmed psychiatric diagnoses. The authors also identified responder bias. The implication is that trauma systems need continuing outcome assessment, while recognising the limitations of the data they collect. [9]

Research also informs the use of resources. An Australian observational evaluation by Gabbe and colleagues compared baseline care, a new ward environment and then a new allied-health model. The allied-health phase was likely to be cost-effective compared with both earlier phases. This supports evaluating investment in rehabilitation, although it does not prove that every staffing change will produce the same effect or that Australian costs can be transferred directly to the NHS. [15]

For commissioners, insurers, healthcare leaders and elected representatives, I believe the relevant question is the total consequence of injury over time. A hospital budget captures only part of that consequence. Continuing care, home adaptations, interrupted employment and the work of relatives also matter. Funding decisions should examine whether services help people regain and sustain participation, as well as what those services cost.

Measuring recovery that matters

Mortality, complications and readmission remain essential measures, but they cannot describe the whole result of trauma care. Follow-up should also capture what the person can do and how they experience life. Validated measures such as EQ-5D, the Glasgow Outcome Scale Extended in appropriate populations, and

WHO's WHODAS 2.0 can contribute. Their results need to be interpreted alongside the patient's own goals and injury-specific assessments. [9,14,16]

The following domains provide a practical framework for discussion. They are not a new validated scoring system. I would use them to prevent a technically successful reconstruction from obscuring an unresolved problem in daily life.

Table 2 Domains to review during functional recovery

Domain	Meaningful evidence of progress
Independence	Daily activities become safer or require less unwanted assistance.
Symptoms and capacity	Pain, fatigue and endurance allow more consistent activity.
Mental health and cognition	Distress, understanding and safety needs are recognised and addressed.
Participation	The person resumes chosen family, community or leisure activities.
Work and education	The return is appropriate, supported and sustainable.
Patient priorities	Progress reflects goals that the person still values.

The final purpose of major trauma care

The early chapters of this book ask what must happen now to preserve life and prevent further injury. This final chapter asks what must happen afterwards to make that survival meaningful to the person who has lived through it. These responsibilities are connected. The choices made during resuscitation and reconstruction shape the possibilities for rehabilitation, while the patient's future life should inform how we judge the success of treatment.

Some people will return to their previous activities. Others will need adaptations, a different occupation or continuing assistance. Our task is to support the best attainable recovery without withdrawing ambition or denying the reality of lasting impairment. A person can live a valuable and fulfilling life with disability, and should have access to the support that makes this possible.

For me, a mature major trauma service continues to care about the person after the wounds have healed and the immediate danger has passed. It treats mental health with the same seriousness as physical health. It listens to families, works with rehabilitation and community colleagues, and learns from long-term outcomes. Functional return is the expression of that continuing responsibility: helping the injured person regain agency and a place in the life they choose.

References

Web resources checked 13 October 2026. Reference numbers correspond to citations in the chapter.

1. World Health Organization. Rehabilitation. Fact sheet. 2024. [Source](#)
2. World Health Organization. International Classification of Functioning, Disability and Health. [Source](#)
3. National Institute for Health and Care Excellence. Rehabilitation after traumatic injury. NICE guideline NG211. 2022. Sections 1.1 to 1.8, 1.11 and 1.13. [Source](#)
4. National Institute for Health and Care Excellence. Rehabilitation after critical illness in adults. Clinical guideline CG83. 2009. [Source](#)
5. National Institute for Health and Care Excellence. Patient experience in adult NHS services. Clinical guideline CG138. 2012. [Source](#)
6. National Institute for Health and Care Excellence. Self-harm: assessment, management and preventing recurrence. NICE guideline NG225. 2022. Sections 1.5, 1.6 and 1.11. [Source](#)
7. National Institute for Health and Care Excellence. Post-traumatic stress disorder. NICE guideline NG116. 2018. Sections 1.6.5 and 1.6.15 to 1.6.20. [Source](#)
8. Bakhshayesh P, Weidenhielm L, Enocson A. Factors affecting mortality and reoperations in high-energy pelvic fractures. *European Journal of Orthopaedic Surgery and Traumatology*. 2018;28(7):1273-1282. doi:10.1007/s00590-018-2203-1. [Source](#)
9. Gabbe BJ, Simpson PM, Cameron PA, Ponsford J, Lyons RA, Collie A, et al. Long-term health status and trajectories of seriously injured patients: A population-based longitudinal study. *PLoS Medicine*. 2017;14(7):e1002322. doi:10.1371/journal.pmed.1002322. [Source](#)
10. National Institute for Health and Care Excellence. Workplace health: long-term sickness absence and capability to work. NICE guideline NG146. 2019. Sections 1.6 and 1.7. [Source](#)
11. Collie A, Simpson PM, Cameron PA, Ameratunga S, Ponsford J, Lyons RA, et al. Patterns and Predictors of Return to Work After Major Trauma: A Prospective, Population-based Registry Study. *Annals of Surgery*. 2019;269(5):972-978. doi:10.1097/SLA.0000000000002666. [Source](#)
12. Day One Trauma Support. Our story. [Source](#)
13. Day One Trauma Support. I have had a traumatic injury and need support. [Source](#)
14. Gabbe BJ, Hofstee DJ, Esser M, Bucknill A, Russ MK, Cameron PA, Handley C, de Steiger RN. Functional and return to work outcomes following major trauma involving severe pelvic ring fracture. *ANZ Journal of Surgery*. 2015;85(10):749-754. doi:10.1111/ans.12700. [Source](#)
15. Gabbe BJ, Reeder S, Ekegren CL, Mather A, Kimmel L, Cameron PA, Higgins AM. Cost-effectiveness of a purpose-built ward environment and new allied health model of care for major trauma. *Journal of Trauma and Acute Care Surgery*. 2023;94(6):831-838. doi:10.1097/TA.0000000000003950. [Source](#)
16. World Health Organization. WHO Disability Assessment Schedule WHODAS 2.0. [Source](#)