6 Initial Assessment and Diagnostics

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Learning Objectives

- Identify the correct sequence of diagnostic priorities for trauma patients per ATLS® criteria.
- Understand the A-B-C-D-E algorithm of the primary survey as it relates to identifying injuries with the highest likelihood of postinjury death.
- Establish the concepts of the primary, secondary, and tertiary survey as part of the diagnostic workup of the polytrauma patient.
- Explain the specific adjuncts to primary and secondary survey.
- Recognize patients who need early consideration for transfer to another facility with appropriate resources and capabilities.

6.1 Introduction

The primary goal of the initial assessment and management of polytrauma patients is survival [1]. Hereby, the term "polytrauma" entails more than simply the sum of all individual injuries sustained by a trauma patient [2]. In these patients, the recognition and early restoration of the "lethal triad" of persistent metabolic acidosis, hypothermia, and coagulopathy is paramount for post-injury survival (Fig. 6.1). The complex underlying pathophysiology renders multiply injured patients vulnerable to preventable complications resulting from an uncoordinated initial diagnostic workup [3, 4]. More than 100 years ago, the "Father of Modern Medicine," Sir William Osler (1849–1919), stated that *"Specialism has fragmented the specialties themselves in a way that makes the outlook hazardous."* This notion is directly applicable to polytrauma where the widely disseminated paradigm of "fragmentation of care" by involving multiple individual specialists to assess and manage the critically injured patient has shown to result in suboptimal outcomes. The "European model" has historically considered trauma as a singular disease, and therefore designated the trauma team as the single "specialist" responsible for the care of the polytrauma patient [5]. The term "polytrauma" is more widely used in European trauma centers, in analogy to the "multiply injured patient" in the United States [6]. Multiple polytrauma definitions have been suggested since the 1970s (Table 6.1). The "Berlin definition" originates form an interna-

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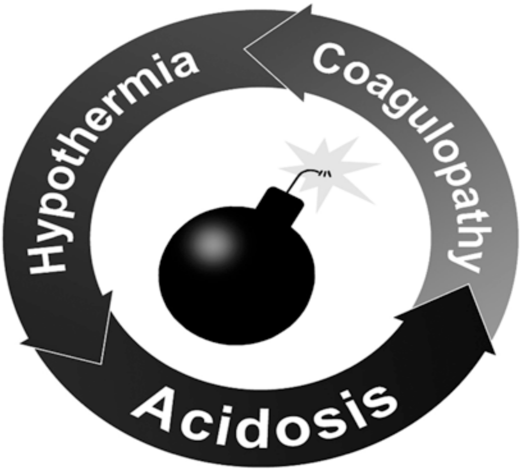

Fig. 6.1 The lethal triad of polytrauma

tional consensus conference and combines anatomic injuries with physiological parameters [7]. The utility and predictive value of the "Berlin definition" has been validated in multiple recent studies [8–10].

Until the 1980s, the delivery of trauma care in the United States was highly inconsistent. The implementation of standardized checklists, such as the "Advanced Trauma Life Support" (ATLS®) protocol, has reduced the variation in diagnostic workup strategies and the delivery of standardized appropriate care, and thereby improved patient outcomes and trauma survival rates [11]. The ATLS® program remains the "key pillar" towards a standardized diagnostic approach in the initial assessment of the and management of the trauma patient [12]. Of note, per ATLS® protocol, identified injuries are managed simultaneously to the initial diagnostic workup [13]. The present chapter was designed to outline the initial assessment and diagnostic work-up of the polytrauma patient, as templated on the ATLS® algorithm that stratifies the initial assessment into a primary and a secondary survey, with selected "adjuncts" available to support the initial assessment and simultaneous management of identified injuries (Table 6.2)

The specific management strategies for individual injuries are described elsewhere in this textbook.

Table 6.1 Historic polytrauma definitions

John Border (1975)	"More than 2 significant injuries in ≥2 body regions"
Harald Tscherne (1984)	"Two or more injuries, among which at least one, or the sum of all injuries, is life-threatening."
Otmar Trentz (2000)	"A syndrome of multiple injuries exceeding a defined injury severity (ISS > 17) with consecutive systemic trauma reactions which may lead to dysfunction or failure of remote—Primarily not injured—Organs and vital systems."
Hans-Christoph Pape (2006)	"Injuries of at least two long bone fractures, or one life-threatening injury and at least one additional injury, or severe head trauma and at least one additional injury."
Butcher and Balogh (2012)	"AIS ≥3 in at least two body regions."
Berlin Consensus Conference (2014)	"AIS ≥3 in at least two body regions, and one or more additional variables from 5 selected physiologic parameters."

Table 6.2 Adjuncts to the initial assessment of the trauma patient

Adjuncts to the primary survey	A	Pulse oximetry Capnography Chest X-ray
	B	Pulse oximetry ABGA eFast Chest X-ray
	C	EKG Foley catheter Gastric catheter eFast AP chest X-ray AP pelvic X-ray
Adjuncts to the secondary survey	A	Repeat chest X-rays
	B	Contrast CT chest
	C	Contrast CT abdomen pelvis Inlet/outlet pelvic X-rays X-rays of long bones Contrast urography Angiography Endoscopy TTE/TEE
	D	Non-contrast CT head CT spine with 2-D recons MRI spine/brain
	E	Additional extremity radiographs

6.2 The Primary Survey

The initial assessment of the trauma patient occurs in two staged phases in the emergency room: the primary and the secondary survey [12]. The tertiary survey is performed in a delayed fashion subsequent to patient admission to the hospital (typically on postinjury day 1), with the intent of reducing the risk of missed injuries that were not immediately life- or limb-threatening at the time of patient arrival [14]. During the primary survey, the injured patient is rapidly assessed by the standardized algorithm of the ATLS® protocol, based on the "A-B-C-D-E" mnemonic:

- **A**irway maintenance, with cervical spine protection
- **B**reathing and ventilation
- **C**irculation and hemorrhage control
- **D**isability: brief neurologic evaluation
- **E**xposure with environmental control (protection from hypothermia)

Hereby, life-threatening conditions are identified and managed simultaneously, and are stratified by a prioritized sequence (ABCDE) based on the effects that specific injuries may have on a patient's physiological response, since it is not possible to define all anatomic injuries during the early phase of the diagnostic workup [12].

6.2.1 A—Airway

The ATLS® protocol mandates that the prioritized sequence of assessment and management is predicated by the extent of the risk of dying. Thus, the injury with the greatest threat to life is managed first. If a trauma patient is able to communicate verbally, the airway is not immediately compromised. However, patients are at risk of losing their airway fast, particularly in presence of high risk associated injuries, such as maxillofacial fractures or smoke inhalation injury. Regardless of the specific injury causing acute airway compromise, e.g., direct physical trauma vs. secondary to traumatic brain injury, the first priority is assurance of a patent airway. If indicated, this implies rapid-sequence endotracheal intubation to provide a safe definitive airway. In rare emergent cases, when intubation is contraindicated or cannot be safely accomplished, a surgical cricothyroidotomy may be required to establish an early definitive airway. Correct positioning of the endotracheal tube is confirmed by auscultation, end-tidal CO_2 monitoring, and a chest X-ray. Every trauma patient receives supplemental oxygen, independent if intubated or not. The bleeding trauma patient's oxygen requirement is illustrated by the historic Nunn & Freeman formula from 1964:

$$O_{2av} = CO \times SaO_2 \times Hb \times 1.34.$$

This formula specifies that the oxygen available in the tissue (O_{2av}) is equal to the product of cardiac output (CO in mL/min), arterial O_2 saturation (SaO_2 in %), and hemoglobin concentration (Hb in g%), whereby 1.34 represents the O2-binding capacity of hemoglobin (in mL/g) [15]. While the oxygen demand is satisfied under physiological conditions, the underlying variables are significantly compromised in the polytrauma patient due to acute blood loss (Hb), pulmonary contusions (SaO_2), myocardial contusion or pericardial tamponade (CO), and therefore result in a severe deficit of oxygen supply for the trauma patient [2].

Of importance, per ATLS® criteria, the cervical spine must be protected from excessive motion during maneuvers to retain the upper airway or perform endotracheal intubation. The protocol mandates cervical spine protection in a C-collar, and by manual in-line traction when the C-collar is opened for acute airway management.

6.2.2 B—Breathing

Airway maintenance alone does not ensure adequate ventilation. Therefore, in second priority to establishing a safe airway, injuries that significantly impair ventilation must be identified and mitigated acutely. These include tension pneumothorax, massive hemothorax, open pneumothorax, and tracheobronchial injuries [16, 17]. Most commonly, a tension pneumothorax acutely compromises ventilation and hemodynamics, and must therefore be excluded due to the imminent threat to life. The clinical symptoms of a tension pneumothorax include acute dyspnea, ipsilaterally decreased respiratory sounds with hypersonoric percussion sound, and congested jugular veins. As a pitfall, congested jugular veins may be absent in patients with hemorrhagic-traumatic shock due to hypovolemia and circulatory centralization. A tracheal deviation to the contralateral side represents a late sign and is rarely detected by clinical inspection of the neck. If a tension pneumothorax is suspected by clinical findings alone, chest decompression must be obtained by puncture of the second intercostal space in the midclavicular line with a large-bore needle. This life-saving maneuver converts the tension aspect into a simple pneumothorax and must be subsequently finalized by the placement of a chest tube. The most frequent cause of tension pneumothorax is mechanical positive pressure ventilation in a patient with chest trauma and an occult visceral pleura injury. When in doubt, a chest tube should be placed in critically injured patients with rib fractures due to the risk of developing a tension pneumothorax after intubation and positive end-expiratory pressure ventilation. Additional critical thoracic injuries other than a tension pneumothorax include flail chest with pulmonary contusions, massive hemothorax, and open pneumothorax, also designated as a "sucking chest wound." Patients with a flail chest may be candidates for early intubation and mechanical ventilation due to the risk of terminal respiratory failure. A massive hemothorax is managed by chest tube placement. However a massive hemothorax with ongoing hemorrhage may require early surgical management by a resuscitative thoracotomy.

6.2.3 C—Circulation

Circulatory compromise in the trauma patient is most frequently due to bleeding and traumatic-hemorrhagic shock [18]. Until proven otherwise, the polytrauma patient is by definition in a state of shock, which must be diagnostic and managed in a timely fashion to prevent early postinjury mortality. Once a tension pneumothorax is ruled out as a cause of shock under the "B" problems, hypovolemia from traumatic hemorrhage remains the main working hypothesis in the initial assessment of the trauma patient. Internal and external sources of hemorrhage must be recognized in a very timely fashion, and the bleeding must be stopped, if necessary, by surgical measures. The immediately available clinical "windows into the microcirculation" include the assessment of pulse (tachycardia), skin perfusion (hypovolemia), and level of consciousness (cerebral hypoperfusion). The additional window into the microcirculation relates to renal perfusion, which can be assessed by quantifying urinary output after placement of a Foley catheter.

In order to estimate the approximate extent of traumatic hemorrhage, the compensatory mechanisms to hypovolemia have to be taken into consideration. For example, the acute blood loss of up to 30% of the circulating volume, which is equivalent to 1500 cc in a patient of 70 kg body weight, does not lead to hypotension due to the increase in peripheral resistance, which masks the true "state of shock" (Table 6.3). However, the cardiac output is reduced to up to half the normal value in this situation, which leads to organ hypoperfusion and metabolic acidosis due to anaerobic metabolism. Therefore, the key question—*"Is the patient in shock?"*—must be addressed early during the primary survey is to determine presence or absence of significant traumatic hemorrhage [13]. This includes a streamlined and standardized approach towards recognizing and controlling external and internal bleeding sources.

6.2.3.1 "Is the Patient in Shock?"—Clinical Assessment

The clinical symptoms of shock are traditionally represented by the "three windows to the microcirculation":

1. Skin perfusion: Patients with a pink skin in the face and extremities are likely not at risk

Table 6.3 Classification of traumatic-hemorrhagic shock[a]

	Class 1	Class 2	Class 3	Class 4
Blood loss	<750 cc	750–1500 cc	1500–2000 cc	>2000 cc
Blood loss (% volume)	<15%	15%–40%	30%–50%	>40%
Heart rate	<100/min	>100/min	>130/min	>140/min
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure	Normal	Decreased	Decreased	Decreased
Respiratory rate	14–20/min	20–30/min	30–40/min	>35/min
Urine output	>30 mL/h	20–30/mL/h	5–15/ml/h	Negligible
Mental status	Normal	Anxious	Confused	Lethargic

[a](per ATLS® criteria [12])

of significant hypovolemia. In contrast, the presence of cold and clammy skin, with ashen-gray facial skin, pale extremities, and delayed capillary refill in conjunction with tachycardia are strong clinical indicators of traumatic-hemorrhagic shock.

2. Cerebral perfusion: When the circulating volume is critically reduced due to hypovolemia, patients may present with an altered level of consciousness due to cerebral hypoperfusion. However, this may represent a late sign of significant hemorrhage due to the physiological autoregulation which retains cerebral blood flow in presence of systemic hypotension. Agitation, confusion, somnolence, or lethargy may represent indirect signs of critical cerebral hypoperfusion in bleeding trauma patients.
3. Renal perfusion: The placement of a Foley catheter allows to monitor the extent of urine production as a surrogate marker of renal perfusion. Patients with severe hypovolemia will present with oliguria (defined as <0.5 mL/Kg BW/h) or anuria. The Foley catheter furthermore allows to detect macrohematuria secondary to renal trauma or urogenital injuries.

These clinical findings help provide a rough estimate of whether a trauma patient is "hemodynamically normal" or just transiently "hemodynamically stable." One of the key aspects of the initial assessment per the ATLS® protocol is to initiate resuscitative measures in parallel to the diagnostic workup, and to monitor the patient's response to resuscitation by continuous clinical re-evaluation [12]. Based on the response to resuscitative measures, patients are stratified into "responders," "non-responders," and "transient responders." The latter cohort of patients are frequently under-triaged due to occult hemorrhagic shock, with a high risk of acute deterioration and fatal outcomes [13].

A persistent base deficit or elevated lactate suggests ongoing resuscitation requirements. The patient's physiological state and response to resuscitation have to be determined early on in order to initiate appropriate timely treatment. For this purpose, trauma patients have been traditionally stratified into the following 4 physiological categories: [19]

Stable

These trauma patients respond to initial therapy and are hemodynamically stable throughout their initial clinical pathway, without clinical or laboratory signs of occult hemorrhage and "hidden shock."

Borderline ("At Risk")

These trauma patients usually typically present with a combination of injury patterns that renders them at risk of poor outcomes. The patients may be under-triaged due to initial response to resuscitation ("transient responders") and rapid subsequent deterioration.

Criteria for identifying these patients include:

- Hypothermia (<36 °C)
- Acidosis (lactate, BD)
- Coagulopathy (INR, aPTT, TEG/ROTEM)
- Severe traumatic brain injury (GCS ≤8).
- Bilateral femur shaft fractures
- Radiographic evidence of pulmonary contusions
- Multiple injuries in association with thoracic trauma or head injury
- Multiple injuries in association with severe abdominal or pelvic trauma

Unstable

Patients in traumatic-hemorrhagic shock at presentation (systolic BP <90 mmHg) will require a fast-tracked abbreviated assessment by the ATLS® algorithm. Non-responders and transient responders will undergo immediate life-saving surgery, as indicated, and timely transfer to ICU for restoration of the "endpoints of resuscitation" (see below).

In Extremis

These patients present in a state of uncontrollable exsanguinating hemorrhage and have a high predicted mortality. These patients are non-responders by definition, and require immediate activation of a mass transfusion protocol (MTP) in conjunction with "damage control" procedures at the bedside, including ED thoracotomy and "crash" laparotomy [20]. Once the life-saving procedures are carried out, patients are transferred directly to ICU for invasive monitoring and ongoing resuscitation.

6.2.3.2 "Is the Patient in Shock?"—Laboratory Tests

A complete blood count (CBC) represents a part of the baseline diagnostic workup for trauma patients. However, the diagnostic value of hemoglobin or hematocrit for occult hemorrhage in trauma patients remains a topic of debate [21]. One major drawback of isolated hemoglobin or hematocrit values is due to the confounding influence of dilution by administration of crystalloids. Recent studies have unequivocally determined that neither isolated nor serial repeat assessment of hemoglobin or hematocrit represents sensitive tests to predict the necessity for emergent surgical intervention in blunt trauma patients with occult hemorrhage [22–24].

In contrast to the poor predictive value of the CBC, both base deficit and serum lactate have been shown to significantly predict the presence of "hidden shock" in trauma patients and to monitor the response to resuscitation [21]. The extent of shock by base deficit is stratified into three categories: mild (−3 to −5 mEq/L), moderate (−6 to −9 mEq/L), and severe (<−10 mEq/L). This stratification provides a significant correlation between the admission base deficit and transfusion requirements within the first 24 h and the risk of postinjury complications and death [25]. It is also important to note that the base deficit is a better prognostic marker of death than the pH, by arterial blood gas analysis [26]. The base deficit has been stablished as a highly sensitive marker for the extent of post-traumatic shock and mortality, both in adult and pediatric patients [26, 27]. In essence, a base deficit below −5 mEq/L by arterial blood gas analysis is associated with a significantly increased rate of postinjury complications and transfusion requirements, whereas a level less than −10 mEq/L is associated with a very high predicted mortality [25, 26]. In contrast, a normal base deficit (or base excess) with values around +2 to −2 mEq/L is associated with a low postinjury mortality around 6% [25, 26].

Historic landmark studies have shown that the serum lactate level on admission represents a "key" predictor for the presence of traumatic-hemorrhagic shock on admission. Abramson and colleagues performed a prospective observational study in patients with multiple trauma to evaluate the correlation between lactate clearance and survival [28]. All patients in whom lactate levels returned to the normal range (≤2 mmol/L) within 24 h survived. Survival decreased to 77.8% if normalization occurred within 48 h and to 13.6% in those patients in whom lactate levels were elevated above 2 mmol/L for more than 48 h [28]. These findings were confirmed in a study by Manikis and colleagues who showed that the initial lactate levels were higher in non-survivors after major trauma, and that the prolonged time for normalization of lactate levels of more than

24 h was associated with the development of post-traumatic organ failure [29].

Although both the base deficit and serum lactate levels are well correlated with the extent of traumatic-hemorrhagic shock and response to resuscitation, these two parameters do not strictly correlate. Therefore, the independent assessment of both parameters is recommended for the initial evaluation of the bleeding trauma patient.

6.2.3.3 Postinjury Coagulopathy

Uncontrolled hemorrhage accounts for nearly 40% of all trauma deaths, and around one-third of all bleeding trauma patients present with a coagulopathy on admission [30]. This subset of trauma patients has a significantly increased risk of adverse outcomes and death compared to non-coagulopathic patients with similar injury severity. The diagnostic workup for postinjury coagulopathy includes conventional laboratory tests, such as the international normalized ratio (INR), activated partial thromboplastin time (aPTT), fibrinogen levels, and platelet count [21]. In general, the diagnosis of coagulopathy using conventional assays is determined by the following thresholds:

- Prothrombin time (PT) >18 s
- Activated partial thromboplastin time (aPTT) >60 s
- PT/aPTT >1.5× control values
- INR >1.5 (PT)
- Quick value <70% (PT)
- Platelet count <100 × 10 [9]/L

However, most of the conventional coagulation tests were developed to monitor anticoagulant therapy, and therefore reflect a crude and artificial in vitro assessment of coagulation. The pure reliance on in vitro coagulation tests (which are performed at a normal pH and a temperature of 37 °C) does not reflect the "true" in vivo coagulopathy in hypothermic and acidotic trauma patients [31]. In addition, the testing by conventional coagulation parameters is associated with a significant delay of around 20–30 min until results are available, and the patient's state of coagulopathy will have changed by the time results are available, due to ongoing resuscitation efforts.

These significant limitations of conventional laboratory tests are mitigated by modern "point of care" coagulation assays, using thromboelastography (TEG) or rotational thromboelastometry (ROTEM) [32]. These modalities are performed quickly at the bedside, and thus represent a "real-time" assessment of coagulation in the bleeding trauma patient.

For further information on this selected topic, the reader is referred to a separate dedicated chapter in the book (see Chap. 10, *"Trauma-induced coagulopathy").*

6.2.3.4 Imaging Studies

Historically, the classic "triad" of plain radiographs obtained in the ED per protocol included a portable X-ray of the chest, a.p. pelvis, and a lateral cervical spine view. The lateral cervical spine X-ray was removed from the latest tenth edition of the ATLS® manual (a) due to the traditional difficulty of obtaining an appropriate lateral view at the bedside, and (b) due to the advent of the multi-slice CT scan technology, which largely replaced conventional spine radiographs in the diagnostic trauma workup [12].

The a.p. chest X-ray allows to detect a pneumothorax, hemothorax, widened mediastinum, displaced rib fractures, and severe pulmonary contusions. In additional, if the clinical diagnosis of a tension pneumothorax is missed, the X-ray may additionally demonstrate a tracheal deviation and mediastinal shift [16]. The a.p. pelvic X-ray is obtained to rule out pelvic fractures or pelvic ring disruptions as a major cause of retroperitoneal bleeding [33].

The rapid ultrasound assessment using a "focused assessment with sonography in trauma" (FAST) protocol has been an established adjunct to the primary survey since the 1990s, as a rapid bedside modality for detection of intra-abdominal free fluid in trauma patients. Over time, the FAST exam largely replaced the historic role of a diagnostic peritoneal lavage (DPL) [34]. The FAST exam has a high specificity (up to 0.99), but low sensitivity (around 0.7), for diagnosis significant intra-abdominal injuries [34]. In the twenty-first century, the FAST paradigm was expanded to the eFAST protocol (“extended focused assessment with sonography in trauma”) to include the assessment of intrathoracic injuries, such as pneumothorax, hemothorax, and cardiac tamponade [35]. The eFAST ultrasound technique relies on the following five diagnostic windows:

1. Right upper quadrant view for detection of free fluid in the right pleural space and between the liver and the right kidney (hepatorenal recess or “Morison pouch”).
2. Left upper quadrant view for detection of free fluid in the left pleural space and between the spleen and the left kidney (splenorenal recess or “Koller pouch”).
3. Anterior thoracic view for detection of missing pleural sliding on the right and left side of the chest.
4. Subcostal/subxiphoidal 4-chamber view for detection of fluid inside the pericardial sac.
5. Pelvic view for detection of free fluid in the rectovesical cavity between the rectum and the bladder (“Proust pouch”) in males, or in the rectouterine cavity between the rectum and the posterior wall of the uterus (“Douglas pouch”) in female trauma patients.

The role of computerized tomography (CT) scanning of acute trauma patients has significantly increased since the introduction of multislice CT (MSCT) scanners [36]. The integration of modern MSCT scanners in the emergency room area allows the timely assessment of trauma victims with high sensitivity for detecting occult injuries [37]. While the conventional diagnostic approach per ATLS® protocol in the 1990s was shown to require around 45 min to establish a working diagnosis, the implementation of modern MSCT scanners in the twenty-first century decreased the time to definitive diagnosis to around 12 min, with a higher sensitivity and specificity [38]. A faster and more accurate diagnosis is associated with shorter times spent in the ED and improved timeliness for achieving definitive bleeding control. Furthermore, contrast medium-enhance MSCT imaging has largely replaced the historic “gold standard” aortogram for assessment of aortic injuries, and allows for detection of occult vascular injuries and bleeding sources with high sensitivity [12].

If a MSCT is not available in the emergency room, the diagnostic workup by CT scanning implies transportation of the patient to the radiology suite, which implies a risk of transportation. Transfer times for diagnostic imaging must be carefully balanced against the risk of prolonged transportation times, particularly in hemodynamically unstable trauma patients. Therefore, stringent institutional protocols must be in place to streamline critical patients to the operating room in absence of CT scanning, if indicated. Of critical importance, the initial assessment and diagnostic workup of traumatic bleeding are paralleled by the simultaneous management of internal and external bleeding sources as those are recognized, in conjunction with appropriate fluid resuscitation and blood product replacement.

Since the management strategies for specific injuries are beyond the scope of this chapter, the reader is referred to the respective dedicated chapters in this book (see Chaps. 7–10 and 16–19).

6.2.3.5 Monitoring Resuscitation

Subsequent to the diagnostic workup and simultaneous management of acutely life-threatening injuries, the critically injured patient is transferred to the ICU as soon as possible, with the intent of restoring the defined “endpoints of resuscitation”: [39]

- Stable hemodynamics, without the need for vasoactive or inotropic stimulation
- No hypoxemia or hypercapnia
- Serum lactate <2.5 mmol/L
- Normal coagulation (INR, TEG/ROTEM)
- Normothermia (>36 °C/96.8 °F)
- Normal urinary output (>1 mL/Kg BW/h)

6.2.4 D—Disability

The fourth priority during the primary survey consists of a brief neurologic evaluation, including quantifying the Glasgow Coma Scale (GCS) score, assessing pupillary size and reaction, and

Table 6.4 Glasgow coma scale

Original scale	Revised scale	GCS score
Eye opening (E)[a]		
Spontaneous	Spontaneous	4
To speech	To sound	3
To pain	To pressure	2
None	None	1
	Non-testable	NT
Verbal response (V)[a]		
Oriented	Oriented	5
Confused conversation	Confused	4
Inappropriate words	Words	3
Incomprehensible sounds	Sounds	2
None	None	1
	Non-testable	NT
Best motor response (M)[a]		
Obeys commands	Obeys commands	6
Localizes pain	Localizing	5
Flexion withdrawal to pain	Normal flexion	4
Abnormal flexion (decorticate)	Abnormal flexion	3
Extension (decerebrate)	Extension	2
None (flaccid)	None	1
	Non-testable	NT

Best possible score: 15. Worst possible score: 3

[a] The GCS score is calculated as E + V + M

determining presence and level of spinal cord injury. The GCS is a historically established, rapid, simple, and objective methods for quantifying the level of consciousness (Table 6.4). A decrease in a trauma patient's level of consciousness may indicate decreased cerebral perfusion and oxygenation, as a surrogate marker of traumatic-hemorrhagic shock, or presence of traumatic brain injury (TBI). The severity of TBI is classified by the GCS as minor (GCS 13–15), moderate [9–12], or severe (GCS 3–8). A patient with a GCS of 8 or less is comatose by definition, which requires endotracheal intubation for airway protection (unless this already occurred as part of "A" in the primary survey). Hypoxia and hypotension must be avoided by all means in patients with TBI, due to the risk of inducing secondary brain insults which are associated with poor long-term outcomes [40]. Patients with severe TBI (GCS ≤8) must be transferred to a trauma center with appropriate resources to manage these critically injured patients, as soon as the patients are considered stable for transfer [41]. A neurosurgical consultation is mandatory for patients with head injuries or spinal cord injuries.

The reader is referred to the respective designated chapters in this textbook (Chaps. 14 and 21).

6.2.5 E—Exposure

The final step in the primary survey consists of a complete exposure of the trauma patient, including a log-roll maneuver to assess the patient's back side, including palpation of the thoracic and lumbar spine, and inspection for presence of soft tissue wounds, lacerations, penetrating injuries, or hematomas (unless this step already occurred under "C" as part of the assessment for bleeding sources) [12]. Since most trauma patients are hypothermic, which increases the risk of exacerbating postinjury coagulopathy, the patient's undressing and exposure are performed with maintenance of environmental control by applying warm blankets, heating lamps, and transfusion of IV crystalloids that are prewarmed to 39 °C (102.2 °F) by the use of high-flow fluid warmers.

6.3 Secondary and Tertiary Survey

The secondary survey does not begin until the primary survey with the A-B-C-D-E algorithm is completed and simultaneous management of identified life-threatening injuries has been accomplished, with improvement of the patient's physiologic response to resuscitation by continuing re-evaluation [12]. In essence, the secondary survey represents a "head-to-toe" evaluation of the trauma patient, including a complete history (as available) and a formal physical exam. The reassessment of vital signs and response to resuscitation continue during the secondary survey. Due to the potential of missing minor injuries during the initial assessment, a standardized tertiary survey is performed on postinjury day 1 and repeated as needed until the patient is fully awake and cooperative with a formal physical examination. Missed injuries are found in up to 39% of all polytrauma patients and mainly relate to fractures around the hand/wrist and foot/ankle [42, 43]. Implementation of a protocolized approach to the tertiary survey allows to close the gap and reduce the ratio of missed injuries closer to zero [14].

6.4 Conclusion

Polytrauma patients are at high risk of postinjury complications and death. The fast-tracked initial assessment and diagnostic workup by the ATLS® protocol allows to identify and manage potentially life-threatening injuries in a prioritized sequence, using a standardized and internationally validated checklist.

Key Concepts

- After securing a patient airway and assuring adequate breathing and ventilation, the next key question *"Is the patient in shock?"* must be addressed by clinical assessment, laboratory parameters, and imaging studies.
- Trauma patients with postinjury coagulopathy have a high predicted mortality. The established "endpoints of resuscitation" must be addressed by ongoing resuscitative measures during the initial assessment.
- The diagnostic workup must allow to determine whether a trauma patient's needs exceed the resources of a facility, with a consideration for early patient transfer to a trauma center with appropriate resources and capabilities.

Take Home Message

- Strict adherence to the priorities of the initial assessment by the ATLS® protocol reduces the risk of preventable postinjury complications and improves trauma survival.

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