5 Point of Injury to Rehabilitation

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- Overall assessment and pre-arrival actions
- Importance of massive haemorrhage control
- Airway signs and basic manoeuvres
- Respiratory assessment
- Cardiovascular assessment and signs
- Clinical neurological assessment
- Exposure and burns assessment

Introduction

The approach to trauma patients has several variables that will shift depending on where they are encountered. Amongst these are the skill level of staff and available resources, location (austere pre-hospital taskings versus a patient arriving packaged in a fully equipped Major Trauma Centre) and the leadership and interpersonal dynamics of the team. All of these factors may influence care and patient outcomes. As discussed in the first section of this textbook, leadership and followership are essential attributes of well-functioning teams of any size. Shared mental modelling helps achieve those goals, but a large part of establishing that model is a common baseline understanding of how to assess and treat patients.

When to Start the Assessment?

The assessment of trauma patients usually begins even before the first responder or team see the patient by consideration of the mechanism of injury. Consider two patients described by a person making an emergency phone call; The first has been hit by a car at five miles per hour and is complaining of leg pain. The second has been hit by a truck at 35 miles per hour and is only grunting or snoring. While there has been no medical input into either of these patients, a mental model of how unwell they are and the potential diagnostic tests or interventions they may require, is already starting to build. These initial pictures from a scene by non-medical staff can dictate the level of response that is sent to the patient and the time in which it arrives. The AMPDS criteria [1] are used by UK medical dispatchers to triage both response times and level of care needed. These depend on responses to questions over the phone and is the first triage and assessment mechanism that is used on patients.

The contents of a pre-alert phone call from the scene should also begin to form a mental model of the patient coming in to the hospital. Indeed, trauma triage tools are routinely employed to

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ensure that the sickest patients are sent directly to Major Trauma Centres rather than peripheral units. Conversely, these tools can also be used to ensure that any patient that is sent to a peripheral unit should be within their capabilities and is unlikely to require a secondary transfer.

The Mechanism of Injury chapter gives further insight into patterns of injury or specific concerns that may be associated with different types of trauma. While these may be immediately apparent to pre-hospital clinicians who meet the patient on scene, they are not always immediately evident to hospital staff. Receiving a patient that is neatly packaged in a well-lit trauma bay without any context can occasionally give a false sense of security. There are two points to note at this stage—for hospital clinicians, a picture paints a thousand words. Photos of a scene can help hospital clinicians immeasurably in gaining an understanding of the forces involved in patients' injuries. It may also help them to understand why everything has not been done to perfection. If only one cannula has been inserted or a blood sugar measurement omitted, it is not uncommon to hear some hospital staff complain. However, when shown a picture of the severely deformed vehicle, upside down, in the rain, at night, in the middle of nowhere from which the patient was extricated, there is suddenly more understanding (and appreciation) of the skill and hard work necessary to get the patient from scene to hospital, resuscitated and packaged well.

The second point is that once the pre-hospital team leaves, so too does any information from the scene that has not been written down or handed over to the hospital team. Make sure that all the relevant information follows the patient! Significant injuries that are seen or suspected should always verbally be handed over to the team leader and documented by the departing staff. Not everything that is said is always heard or understood, and a written record of the scene, injuries and treatment can be of great use when assessing patients later on in intensive care or the ward.

It should be noted that trauma does not always exist in isolation; patients can have traumatic injuries as a result of a medical insult. In the context of a road traffic collision, for example, information from the scene can have a direct influence on management in the hospital. A patient who has crashed their car on a straight road in clear conditions may have had a medical event before their traumatic one, and this may influence subsequent management. A patient who has had an arrhythmia and then suffers a cardiac arrest with minimal traumatic injuries is NOT a candidate for a resuscitative thoracotomy, and this should be borne in mind.

The Reprioritisation of Haemorrhage Control

Historically (and in other non-trauma resuscitation courses), students are taught the ABC approach to patient management—airway, followed by breathing and then assessment of the circulation. Safar first established this in his 1961 publication on ventilation and closed-chest compression [2], an early predecessor to the current Advanced Life Support course. In current trauma practice, this approach is suboptimal because of two factors; firstly, it negates the clinical concept and importance of massive haemorrhage taking priority. Data from military experience has shown that most battle casualty deaths occur within 10 minutes of injury, and the majority of deaths are from exsanguination [3]. Of these deaths, while truncal haemorrhage is the leading cause, the same paper demonstrated that 18% of the deaths that were attributable to bleeding were from limb or neck wounds that were potentially compressible. The paper argues that these deaths were potentially preventable with the correct training. In a traditional ABC approach, these wounds would not have been addressed as a priority, and not at all until airway and breathing had been assessed and treated as needed. The short period from injury to death in these papers emphasises that speed in circulation preservation is necessary. To further highlight this approach, an article by Eastridge in 2012 [4] and a further review in 2019 [5] have concluded that in those who died in combat, 90% of potentially survivable injuries were due to haemorrhage. With more training, reprioritisation of massive haemorrhage control and use of tourniquets in self- and buddy-aid, there was an 85% drop in deaths attributable to limb haemorrhage. A further paper by Kragh et al. [6] showed that early and aggressive tourniquet usage in severe limb trauma before the development of shock was associated with a significant survival improvement (90% vs 10%). These findings, while based on military data and experience, are echoed in civilian practice. A 2007 Canadian paper by Tien et al. [7] concluded that 16% of trauma deaths were potentially preventable with earlier and more aggressive haemorrhage control. A 2005 paper from the USA by Dorlac et al. [8] suggested over 50% of patients who exsanguinated and died from isolated extremity injuries could potentially have been successfully treated with tourniquet application early on in their care. These data have renewed the emphasis on massive haemorrhage control, placing it above airway as the initial priority in trauma care.

The second difference is that the way trauma patients are assessed and treated has evolved, and reflects what has already been discussed in the Trauma Systems and Teams section of this textbook. The Advanced Trauma Life Support course was revolutionary when it was first developed in the late 1970s and has undoubtedly saved many lives by standardising the approach to trauma since its inception. However, the model of trauma care that it was initially aimed at was for a single practitioner with an assistant working in a remote hospital with minimal resources and access to specialist expertise. Out of necessity, it stressed a methodical ABCDE approach with the idea to treat the pathology that kills first before moving onto other systems. Modern trauma care is different in that our understanding of treatment and pathology has evolved over 40 years, and that (except for small pre-hospital teams) most in-hospital trauma teams are large enough to diagnose and treat multiple systems concurrently. While ATLS teaches an individual to assess and treat a patient sequentially, a more modern approach favours a team working in parallel (rather than sequence) to diagnose pathology in multiple systems concurrently, led by a "hands-off" team leader. This has also been termed "horizontal" resuscitation as opposed to the previous "vertical" approach [9]. Earlier, more aggressive investigation and treatment of haemorrhage has led to improved outcomes after reprioritising circulation preservation with tourniquets and other methods as described above. A further adaptation that has been used in horizontal resuscitation is the concept of "3D" resuscitation [9], where the trauma team leader may identify a small group of patients based on pre-hospital information who may benefit from transfer direct to the operating theatre from the ambulance. This approach was employed in Camp Bastion during the Afghanistan conflict where it was termed "Right Turn Resus" as the doors to the operating theatres were originally on the right as the patient was wheeled into the Resus department. The trauma team could assemble in the operating theatre and perform ED resuscitative measures at the same time as surgical control of bleeding and damage control. Patients who benefit from this approach are the most severely injured (e.g. explosive injuries with limb loss and/or multiple torso injuries and cardiovascular collapse) [9, 10].

A Universal Treatment Algorithm

For these reasons (and others outlined in the Massive Haemorrhage Chapter), an MABCDE approach is advocated:

- **Major haemorrhage control**
- **Airway with c-spine consideration when needed**
- **Breathing**
- **Circulation**
- **Disability**
- **Exposure/ Environment/ Everything else.**

This has also been referred to as a MARCH approach (Massive haemorrhage, Airway, Respiration, Circulation, Head injury/ Hypothermia). However, in all honesty, it does not matter which mnemonic is used—the result is the same. This textbook employs the MABCD approach as it is usually the most familiar, or at least provides the least deviation from a well-known and taught system from other areas of medicine while emphasising the importance of aggressive circulation preservation. Each section of the mnemonic has a dedicated chapter later in the textbook. However, the critical thing to bear in mind is that for a primary survey, clinicians should only be looking to detect and treat immediately life-threatening injuries and not perform an exhaustive examination. The availability and speed of modern imaging in hospital usually means that patients can rapidly have appropriate radiological examinations (usually contrast-enhanced CT) within 30 min of arriving in hospital. The MABCD approach emphasises treating conditions which will either kill the patient before they can be detected by imaging, or identify patients who should go straight to the operating theatre and bypass CT altogether if they are too unstable. However, it is essential to point out that the most unstable patients may have the most to gain from whole-body CT imaging [11]. Even in haemodynamically unstable patients, modern CT scanners are so quick that a CT scan may avoid operative management in nearly 50% of patients who previously would have gone straight to theatre [12]. More details are available in the Radiology in Trauma section.

Overarching Principles of MABCD

Each step of the MABCD approach in the initial assessment emphasises a swift damage control approach:

- Preserve circulation
- Ensure adequate oxygenation
- Promote normalising physiology
- Avoid secondary injury

As patients progress further through the chain of resuscitation, the options available to clinicians increase. However, the overarching aim during initial resuscitation remains unchanged—to identify and treat time critical pathology before moving on. While this may occur concurrently in well-resourced teams as described above, the same MABCD sequence and principles apply to both large teams and solo responders. Specific interventions may be beyond the scope of practice of an individual, or impractical due to their location. If severe pathology is suspected, it is incumbent on the clinician to highlight their concerns when handing over the patient to the next level of care to ensure that they are addressed and not forgotten. Time is one of the most precious and scarce commodities trauma patients have, and it should not be wasted. If intervention is needed that is not available, then an expedited transfer should be considered as much a resuscitative measure as an operation. Spending time either on scene or in a resuscitation bay in an attempt to "fully" resuscitate patients before moving them to the operating theatre or CT scanner is wasteful of both time and resources. It may result in worsening hypothermia, acidosis and coagulopathy as described in the Damage Control chapter.

It may be that patients suffer a significant degree of trauma and go into cardiac arrest as a result of this. If there are absent signs of life on any of the ABC assessments, it may be appropriate to perform a resuscitative thoracotomy. This is only appropriate in the presence of specific pathologies, and when the absence of vital signs is thought to be due to a low-flow state. Again, it is worth emphasising the importance of context as a trauma thoracotomy will not fix a medical problem!

Massive External Haemorrhage

Massive external haemorrhage refers to imminently life-threatening bleeding, e.g. a femoral or brachial artery transection that can approach 1000 ml/min blood loss. True massive external haemorrhage rarely presents untreated to hospital. Due to response and transport times, patients who have these injuries and are not rapidly treated will exsanguinate and die before arrival. In pre-hospital medicine, these injuries are critical to identify and promptly treat. As previously described, there has been a significant decrease in preventable mortality as a direct result of education in the military. There are now civilian programmes such as "Stop the Bleed" [13–15] which are teaching the use of tourniquets and other circulation preservation techniques to the public. The general DIT escalation approach (Direct pressure, Indirect Pressure, Tourniquet) is covered in the massive haemorrhage chapter, and it should take less than one minute to establish control.

The total circulating volume of an adult is approximately 70 ml/kg, or around 5000 ml—as much of this volume as possible should be preserved rather than being replaced (see damage control chapter for more information). In children, circulating volume is around 80 ml/kg, but the absolute volume is lower than in adults, so effective haemorrhage control is even more critical. Younger children are not able to adapt their cardiovascular physiology as well as adults and consequently tolerate hypovolaemia poorly, with sudden and catastrophic deterioration when they can no longer compensate. Looking for signs of bleeding and aggressive treatment is necessary. Any blood-soaked clothing or obvious spurting bleeding should be considered due to treatable massive external haemorrhage until proven otherwise in both adults and children.

Tourniquets have enjoyed a resurgence in popularity in the last 15 years, and multiple models are now available for purchase. There are even more options which may be available in-hospital such as pneumatic devices which are in everyday use for elective orthopaedic surgery. These devices increase pressure over a larger area, so may be tolerated better by patients and decrease the risk of nerve or tissue damage in comparison to windlass devices. Another advantage of using any form of tourniquet is freeing up other practitioners. Massive haemorrhage control may only be achievable by constant external pressure over a wound which takes one clinician out of the team. If the injury is amenable to compression with a tourniquet of some description, then the clinician can be freed up to continue with assessment and treatment once the tourniquet is in place and tightened/inflated.

Airway

Trauma patients who can talk are much easier to assess. The fact they can speak at all tells the clinician that the airway reflexes are almost certainly intact, their airway is *currently* patent, they can breathe sufficiently to talk and have a sufficient blood pressure to perfuse their brain. It is also a particularly useful assessment method if the patient is concealed, entrapped or not immediately visible when the clinician arrives on the scene.

If the airway is not clear, it will need addressing as the next priority after massive external haemorrhage has been controlled. There may be a primary airway issue if there is facial or neck trauma. Alternately, airway compromise may be secondary to a decreased level of consciousness following a head injury, administration of drugs, or metabolic disorder such as hypoglycaemia or hypercarbia. Considerations relevant to airway management are discussed more fully in the airway chapter, but all clinicians should have mental schemata in mind to escalate from basic manoeuvres with simple adjuncts to more advanced options. Even if unable to perform some of the more advanced techniques themselves, clinicians should be able to recognise and communicate concerns about a threatened or failing airway. This enables preparations to be made by the next level of care and save valuable time.

Airway obstruction can be partial or complete. Depending on the cause, partial airway obstruction may present as a hoarse voice (in the case of inflammation due to infection or inhalation burns), snoring, gurgling noises or coughing or gagging. If a sound is heard, then some degree of air is moving past the vocal cords, but a noisy airway is a warning of potential imminent obstruction. Airways can become obstructed by a range of substances such as blood, vomitus, teeth, foreign bodies or food or other debris and symptoms and signs seen should be related to the underlying mechanism of injury. Treatment is directed towards the underlying cause and can range from repositioning the patient and suction to intubation or a surgical airway as needed in evolving airway swelling such as in burns or chemical inhalation.

In complete airway obstruction, there is no noise at all; this is an immediately life-threatening emergency. Again, this can be a primary or secondary airway issue, but without manoeuvres or procedures to open the airway unconsciousness and death will swiftly follow. The patient may demonstrate "see-saw" breathing [16], where the diaphragm contracts against a closed airway and distends the abdomen but causes the chest to be drawn inwards during attempted inspiration. During expiration, the opposite occurs, and the abdominal muscles contract inwards in an attempt to increase intrathoracic pressure and expel air. The closed upper airway leads to slight distension of the chest at this point as a result, and a rocking motion is seen across the diaphragm. Again, the treatment can escalate from simple manoeuvres to surgical airway along the airway ladder, depending on the underlying cause.

Reassessment of patients regularly is essential to quantify both responses to treatment and evolution of pathology. Patients who have been given certain medications with analgesic or sedative properties are at risk of losing control of their airway, as are patients with decreased cerebral perfusion due to ongoing hypovolaemia or evolving intracranial pathology.

Breathing

All trauma patients in the initial period should be given high flow oxygen as a safety measure until a rapid primary survey has been concluded and ongoing oxygen requirement has been assessed. This is consistent with the British Thoracic Society guidelines on emergency administration of oxygen [17] and includes patients with a history of lung disease. There is frequent concern about a minority subset of patients who have chronic type two respiratory failure and may not tolerate high flow oxygen without becoming hypercapnoeic. These patients are a tiny minority of patients who suffer from trauma. Frequent reassessment of the patient (which is the hallmark of an excellent primary survey) will alert the clinician to a susceptible patient who may be deteriorating as a result of oxygen administration. Far more harm is likely to come in trauma from restricting access to oxygen for those who require it than giving it for short periods to patients who may not. In patients who are known to have type two respiratory failure and are chronically hypoxic, once the initial survey is complete the oxygen concentration can be decreased to achieve their usual target saturation (usually an SpO_2 of 88–92%). It must be again stressed that this target is for a tiny minority of patients with severe chronic lung disease who have been injured — the vast majority of patients should be given supplementary oxygen to achieve saturations of 94–98%. A full discussion of oxygen-induced hypercarbia is beyond the scope of this textbook, but an excellent article by Abdo and Heunks [18] explains the physiology behind oxygen-induced hypercapnoea and the often quoted myth of "hypoxic drive" for those who are interested.

Monitoring of patients on oxygen is essential, and this is achieved using multiple data points. Firstly by looking at the oxygen mask. This should mist every time the patient exhales due to water vapor in the patients' upper airway. In some models, a brightly coloured polystyrene ball will lift with expiratory effort as a visual aid to count respiratory rate. In some cases, end-tidal waveform capnography can be used to monitor respiratory rate. It must be noted, however, that outside of ventilated patients the absolute $EtCO_2$ value is inaccurate. The respiratory rate can still be used, but due to mixing with entrained air or oxygen, the displayed value of the peak $EtCO_2$ will under-read. In addition to $EtCO_2$ monitoring, the most useful monitor that should be applied at the earliest opportunity is the pulse oximeter. Not only will it give information about oxygen saturation (SpO_2), most models will display a pulse rate and a rhythm plethysmograph, which can indicate an irregular pulse. In addition to this, the oximeter can be a crude surrogate marker of perfusion. A trace will only be picked up in reasonably perfused fingers, and in significantly hypovolaemic states it may not pick up at all. The other clinical pitfalls to avoid are poor or absent traces in patients who are cold or have fake/

painted nails, and unreliable SpO_2 readings in patients with certain abnormal forms of haemoglobin after toxin inhalation (e.g. carboxyhaemoglobin or methaemoglobin). Depending on patient location and available equipment, blood gas analysis may also be possible. This is a useful point of care test that can rapidly give information on oxygenation and ventilation parameters as well as acid-base balance, base deficit, levels of electrolytes, haemoglobin and lactate.

During the primary survey, the initial focus is on detecting and treating life-threatening pathology, which can be found on clinical examination or with the use of near-patient testing modalities such as ultrasonography or plain film x-rays. Due to the initial supine positioning of patients in the trauma bay, it can be challenging to assess for posterior wounds unless the patient is rolled onto their side. Similarly, in patients transported with their arms by their sides, it is not uncommon to miss axillary wounds—these must actively be sought out as part of the primary survey. The neck and abdomen border the thoracic cavity, so injuries in these areas should raise suspicion of intra-thoracic damage too.

There are many mnemonics to use for clinical examination, and FLAPSS (Feel, Look, Auscultate, Percuss, Search Sides and back) is a useful one. A caveat is that in noisy environments (in hospital as well as pre-hospital), the usefulness of auscultation can be limited [19]. An assessment following this methodology should pick up at least some of the signs of chest pathology, which is fully covered in the breathing chapter. Evaluation of the chest should also include the neck, and the mnemonic TWELVE (Tracheal position, Wounds, Emphysema, Laryngeal crepitus, Venous distension and Everything else) can be used.

After any significant intervention, re-examination and reassessment should be performed. Specifically, post-intubation checks should assess for the evolution of pneumothoraces and correct tube placement. As previously mentioned, auscultation can be limited in utility and there may be a role for ultrasonography in detecting significant pathology. For example, lung sliding can be used to assess for pneumothorax—if both lungs are seen to move under the pleura, then this is reassuring that there is no pneumothorax. The sensitivity of ultrasound is much higher than plain film x-ray for anterior pneumothoraces [20] and can be combined into other ultrasonographic assessments for trauma (e.g. e-FAST or RUSH protocols), which may also reveal haemothorax. A pitfall for the unwary is malposition of an endotracheal tube. If the tube is advanced too far, it will usually pass into the right main bronchus and not ventilate the left lung at all. This will also cause an absence of lung sliding (although lung pulsation will still be seen), absent breath sounds on the left and hypoxia, which could equally be suggestive of a pneumothorax. Before intervening, check that the tube is not too far in!

Other respiratory pathology may be apparent following intubation, such as decreased lung compliance (needing higher pressures to inflate the lung than would typically be necessary), increased A:a gradient (hypoxia despite additional oxygen supply) and difficulties in gas exchange.

Circulation

Circulatory assessment is the fourth stage in the primary survey, though some clues may already have been apparent about circulatory status from the initial steps. If a patient is talking coherently, then their circulation is adequate to perfuse their brain. This is to say that perfusion is *sufficient* rather than *normal*. Initial circulatory assessment includes the presence or absence of peripheral pulses (radial, femoral and carotid), a heart rate and capillary refill time.

Further assessments such as blood pressure and heart rate can come when monitoring is applied, but in the initial stage, these first measures can give a gross estimate of current circulatory status within seconds. Historically it was taught that a radial pulse equated to a systolic blood pressure of 80 mmHg, a femoral 70 mmHg and a carotid 60 mmHg. While these specific figures have been debunked [21], the order in which the pulses disappear is generally sound [22]. Patients who have a decreasing level of consciousness should be assessed for bleeding as a cause. This includes patients who appear to be confused, agitated or intoxicated—the underlying cause may be that they are not perfusing their brain due to hypovolaemia.

Patients who are suspected of having ongoing bleeding should be rapidly assessed and appropriately imaged to shorten the time to a definitive haemostatic procedure, either radiologically or surgically. Until diagnostic imaging is obtained, patients with a significant mechanism of injury and clinical signs compatible with ongoing bleeding should be considered to be actively bleeding still. Administration of tranexamic acid, appropriate use of blood products and other resuscitative measures are discussed in the circulatory chapter. Sites of blood loss are generally remembered by the saying "Blood on the floor and four more" This refers to external bleeding and internal bleeding into either the chest, abdominal or pelvic cavities and long bone fractures. Acutely, circulation preservation should be the aim. Treatments such as pelvic binders and long bone traction and splintage should be considered resuscitative measures for circulation, as much as for orthopaedic or analgesic reasons.

Hypoperfusion of tissues will also cause disturbances in acid-base balance as described in the circulation chapter. Hypoperfusion causes the production of lactate, resulting in an increasingly negative base excess and fall in pH. If severe (pH < 7.2) this may adversely affect clotting and other enzymatic dependent systems. Young patients will generally compensate for blood loss for an extended period in terms of maintaining their blood pressure, so hypovolaemia is a relatively late sign of bleeding. One American retrospective study of 115,000 trauma patients showed that by the time patients became hypotensive due to blood loss, their base deficit was already −20 and their overall mortality approached 65% [23]. Potential other causes of hypotension are tension pneumothorax or neurogenic shock; however, all hypotension in trauma should be considered to be due to hypovolaemia until proven otherwise. Similarly, a normal haemoglobin level does not rule out bleeding, as the concentration of the remaining blood will initially remain the same. A low haemoglobin level (<11 g/dl) should definitely raise the concern of acute blood loss and prompt a damage control approach.

Cold patients may have a prolonged capillary refill time (CRT) peripherally, so CRT should always be tested on either the sternum or forehead to ensure validity. As well as increasing CRT, cold patients may be developing a coagulopathy. This is partially because of the reduced effectiveness of enzymes involved in blood clot formation at lower temperatures, but also due to the degree of blood loss that must occur to induce hypothermia. Coagulopathy can occur independently of hypothermia, and as many as 30% of major trauma patients may have developed a coagulopathy by the time they arrive at the emergency department. This traumatic coagulopathy is independently associated with a poorer outcome [24–27]. If present on admission, hypothermia is also associated with a nearly threefold increased mortality in some studies [28–31] and should be aggressively treated by heating the patient, the treatment environment and any IV fluids, including blood products.

If a patient arrests as a result of trauma, then the correct management is to follow a traumatic cardiac arrest protocol, which is different from the usual ALS guidelines. This is discussed further in the traumatic cardiac arrest chapter, and interventions may include resuscitative thoracotomy if indicated in selected patients. This group is mainly those patients who have a witnessed arrest due to chest trauma and relatively short down time with a potentially amenable underlying cause. If a patient suffers a cardiac arrest as a result of a medical reason, resuscitative thoracotomy is not indicated. Medical and traumatic cardiac arrests are very different clinical entities and should be treated as such.

Disability and Head Injuries

Assessment of neurological status is the next step in trauma management, beginning with the level of consciousness. Formally, the Glasgow Coma Scale (GCS) is the accepted and validated method of assessing the level of consciousness in head-injured patients [32, 33]. GCS is a score from 3–15 depending on the level of consciousness, and there is a stepwise progression in mortality as the score falls (I.e. the patient becomes more unconscious) [34]. GCS is a useful score and is understood when making referrals, but can occasionally be challenging to remember how to calculate. A simpler alternative is AVPU. This stands for Alert, responds to Voice, responds to Pain stimuli or Unresponsive. In some areas, Confusion has been added as a variable between “alert” and “responds to voice” as another method of describing the level of consciousness (ACVPU). Trends over time are useful as patients with head injuries who are becoming more drowsy or unconscious should be treated as time-critical patients, mandating urgent imaging. Decreased level of consciousness can be due to medical as well as traumatic causes (e.g. hypoglycaemia, seizures etc.), and a medical cause of unconsciousness may have caused a traumatic injury, e.g. hypoglycaemia causing a patient to crash their car.

Neurological defects that are present at the point of presentation are significant to note, as patients who are becoming progressively more unresponsive may require anaesthesia for airway protection. The opportunity to examine for gross lateralising signs that may indicate a stroke, spinal cord injury or other neurological concerns may be lost once the patient is intubated. In the case of head-injured patients, waking them up to examine them may not be an appropriate course of action. Any coughing against an endotracheal tube may increase intracranial pressure and worsen secondary brain injury, so perform a baseline gross neurological exam before anaesthetising patients whenever possible.

Pupillary reflexes should routinely be examined as part of a neurological assessment, and any differences between sides should prompt urgent evaluation and treatment. If a patients’ pupils are unreactive in head injury, then this is an emergency. However, the outcome may not be as nihilistic as previously believed depending on the presenting pathology. In a meta-analysis by Scotter et al., over 50% of patients who presented with fixed dilated pupils as a result of extradural haematoma made a good recovery back to independent living [35]. Traditionally, these patients would have been considered to have unsurvivable injuries.

Exposure

The final stage in the primary survey is exposure. This involves removing clothing and examining the patient for any other injuries that have not yet been found or addressed in the MABCD stages. These injuries may include fractures, burns or other significant soft tissue injuries such as degloving. When exposing patients, a balance must be struck between preserving dignity and body heat versus missing a relevant injury. At this point, the patient should be rolled and an assessment made of their back for injuries which may not have been found. It is also essential to consider other areas which have not been visualised and may have significant injuries such as axillae, groins, perineum and buttocks. Stab wounds in these areas can often be missed in unconscious patients, and the Exposure stage of the primary survey should be a trigger to examine them actively. In come centres where access to CT scanning is virtually immediate, patients may be taken to CT first and then exposure completed as part of the secondary survey. In the pre-hospital environment, full exposure may not be appropriate or possible for the reasons outlined above, even more so if patients are entrapped or immobile for another reason. Indeed, attempting to expose an entrapped patient may decrease the speed of extrication and lower temperature, both of which may increase mortality. Selective exposure should be undertaken if needed and if it may change patient management, especially if there is suspicion of penetrating wounds or significant bleeding. Any suspected but unconfirmed injuries which require further investigation in hospital should be handed over as a routine.

An in-hospital pitfall to avoid is an over-reliance on CT scanning to elucidate all injuries. A CT scan is not a substitute for a full clinical examination and secondary survey! This may have to wait if the patient is intubated or unable to speak, but a formal secondary survey should be undertaken as soon as practicable. CT scans typically will image from the vertex of the skull to mid femurs unless a specific request for additional sites is added. Most trauma centres have moved towards using a biphasic contrast scan (occasionally referred to as the Bastion Protocol [36]) as compared to previous methods for contrast CT scanning in trauma. This protocol can acquire excellent images in a shorter time with less radiation dose [37]. While CT scans can provide detailed images of solid viscera, bleeding sites and bony injuries, they may not image tendinous lesions or some other soft tissues well. To ensure no "minor" injuries are missed and good functional outcomes achieved, a targeted clinical examination should be performed as part of the secondary survey. CT scans can be used as a prompt to examine specific areas (in addition to prompts from the mechanism of injury), but should not be relied on to find every injury that needs treating.

Burns patients should also be exposed fully but should be kept as warm as possible to avoid hypothermia. Some regional burns units are co-located at Major Trauma Centres, but this is not always the case. Patients may need to have their initial trauma dealt with at the MTC and be transferred later to a specialist centre, so basic burns care and communication with specialist burns teams should be available at every MTC. The current UK criteria for referral to or discussion with regional burns centres are [38]:

Paediatrics
- **≥ 30% total body surface area (TBSA) burn of any degree**
- **≥ 15% TBSA if under one-year-old**
- **≥ 20% TBSA full-thickness burns**
- **Burns to face, feet, hands or genitalia**
- **Any chemical, electrical or serious friction burn**
- **Any cold injury**
- **Any burn not healing two weeks post-injury**
- **Any patient requiring ventilation for ≥ 24 h due to their burn injury**
- **Any child who is physiologically unstable as a result of burns or in whom a non-accidental injury is suspected**
- **Any burn in a neonate**

Adults
- **≥ 40% TBSA or ≥ 25% with inhalational injury**
- **≥ 25% TBSA if over 65 years old**
- **Burns to face, feet, hands or genitalia**
- **Any chemical, electrical or serious friction burn**
- **Any cold injury**
- **Any burn not healing two weeks post-injury**
- **All patients with major trauma and burn injury after treatment within a Major Trauma Centre.**

Onward Care

After initial resuscitation and treatment, patients should be admitted to a critical care area or a ward appropriate to deal with their injuries depending on their requirements. All patients with an Injury Severity Score (ISS) > 8 should have a rehabilitation assessment and prescription within 72 h of their injury by a rehabilitation medicine consultant. This timeframe can be extended to up to 96 h if the patient is unable to be assessed for clinical reasons before this point. This rehabilitation assessment should cover not only physical functional aspects of recovery but also cognitive/psychological, social and educational aspects of rehabilitation. This should lead to the formation of a specific rehabilitation prescription which can vary from observation only in the case of more minor injuries, through to formal rehabilitation programs in dedicated specialist national centres (e.g. spinal injury units).

Conclusion

The MABCD system of assessment identifies and treats pathology in a logical manner which can be applied in a variety of clinical settings from pre-hospital to in-hospital environments. It ensures that significant pathology is treated in the order that it may kill patients, and provides a standard system that is understood and applied by all members of the trauma team at each stage of progression of the case. In the event of deterioration, reassessment using the same system provides a solid base for identifying progression or evolution of pathology, or identification of clinical signs that may not have been present during the initial assessment. Even in advanced care, the MABCD methodology still forms the basis of the evaluation, and while the tools available to assess each system may be more complex, the underlying principles are the same.

Questions

1. The correct sequence of clinical assessment of trauma patients is:
   (a) ABCDE
   (b) MABCD
   (c) CABDE
   (d) DABC
2. Noisy breathing/gurgling is a sign of complete airway obstruction
   (a) True
   (b) False
3. An SpO2 reading of over 95% on a standard oximeter always indicates normal tissue oxygenation in burns patients
   (a) True
   (b) False
4. Trauma patients who become cold or present with hypothermia have worse outcomes than those who retain a normal temperature
   (a) True
   (b) False
5. Whole body CT of trauma patients will pick up all injuries
   (a) True
   (b) False

Answers

1. b
2. b—complete airway obstruction is silent due to lack of air movement
3. b—inhalation of carbon monoxide or cyanide compounds from burning plastics can falsely elevate SpO2 by creation of carboxyhaemoglobin or cyano-compounds
4. a
5. b

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