

# Prevention of tissue hypoperfusion in the trauma patient: initial management

*This article outlines the challenges of identification and management of tissue hypoperfusion as a consequence of haemorrhagic shock in civilian polytrauma cases. It also describes damage resuscitation, but does not cover specific trauma cases such as pregnancy, burns, head injuries, children and elderly trauma.*

Trauma is the leading cause of death and disability in the first four decades of life, with haemorrhage accounting for about 40% of all trauma deaths (Soreide, 2009; Duchesne et al, 2010). Haemorrhagic shock is defined as 'acute circulatory failure, with inadequate tissue perfusion causing cellular hypoxia' as a result of major blood loss (American College of Surgeons, 2008; Loftus, 2010) (Figure 1).

Initially, the haemorrhaging trauma patient may have normal haemodynamic parameters, because circulatory response (tachycardia, vasoconstriction) prevents a measurable fall in the systolic blood pressure (Guyton and Hall, 2006; American College of Surgeons, 2008; Harris et al, 2012). However, this compensatory mechanism is limited and subsequently hypotension develops as a result of haemorrhage (American College of Surgeons, 2008). The combination of tissue trauma, hypovolaemia and vascular disruption is the key driver of hypoperfusion and the lethal triad (acidosis, hypothermia and coagulopathy) (Figure 2).

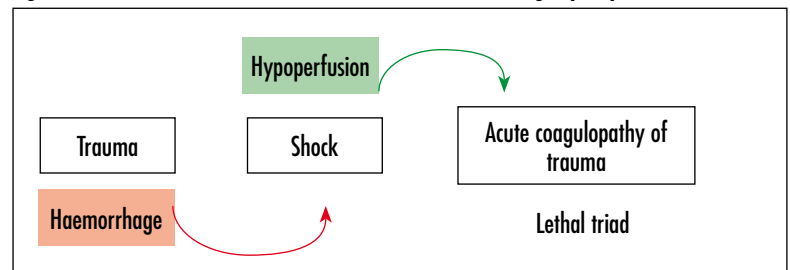
Once the lethal triad develops, it is difficult to restore basic physiological and immunological functions, even with treatment on the intensive care unit (Moore et al, 1998; Stahel et al, 2009; Frith and Brohi, 2010). Therefore, prompt initial pre-intensive care unit resuscitation should aim to reduce systemic inflammatory response syndrome to limit the cellular damage from tissue hypoxia (Dutton, 2012; Manson et al, 2012). Minimized physiological insult leads to an improved clinical course and better outcomes for the trauma patient (Dutton, 2012; Manson et al, 2012; Schreiber, 2012).

## Mechanism of injury

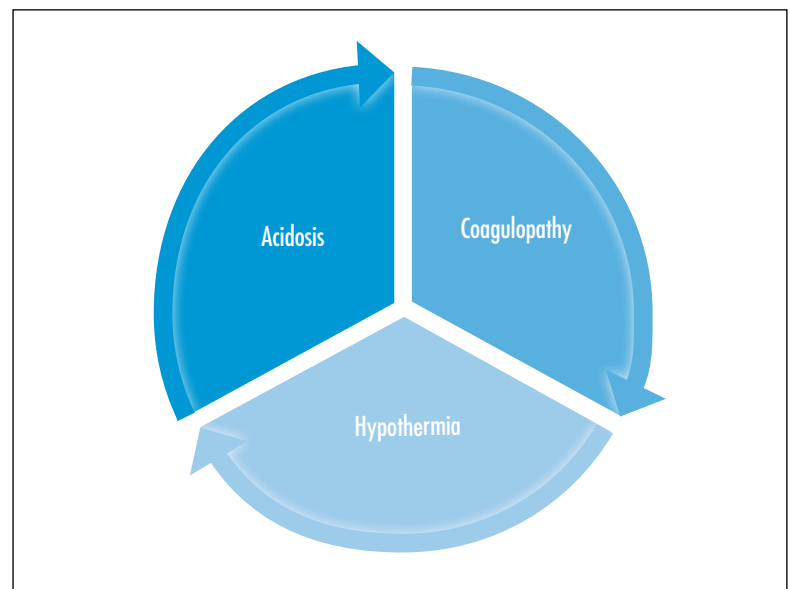
When a trauma victim arrives in the emergency department, it is essential to ask the ambulance crew about the mechanism of injury before the primary survey takes place. This provides invaluable information regarding the energy transfer, deceleration mechanisms, compression and shear forces involved. Knowledge of the mechanism of injury helps to predict possible bony, visceral, soft tissue and vascular injuries (American College of Surgeons, 2008; Rossaint et al, 2010). This is particularly important in a blunt trauma with no obvious skin penetration, where transferred energy can cause tissue damage a sig-

nificant distance from the site of initial impact (American College of Surgeons, 2008). It is also important to remember that, in penetrating injuries, the entry wound can be disproportionately smaller than the actual internal damage. Therefore, understanding the biomechanics of an injury can guide the clinician's decision about whether to request immediate full body computed tomography or the standard trauma series X-rays, which can often be unremarkable in spite of significant tissue damage (Rossaint et al, 2010).

**Figure 1. Associations between trauma, shock and acute coagulopathy of trauma.**



**Figure 2. The lethal triad of acidosis, hypothermia and coagulopathy.**



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### Primary survey

Subsequently, the primary survey is performed and traditionally the Advanced Trauma Life Support (ATLS) ABCDE principles are used (American College of Surgeons, 2008). A stands for Airway and c-spine control, B is for Breathing and ventilation, C describes Circulation and haemorrhage control, D assesses the Disability and neurological status and E is focused on full body Exposure and aims to prevent hypothermia. The ABCDE approach is used among clinicians worldwide to identify and treat immediately life-threatening problems in a logical manner (American College of Surgeons, 2008). The ABCDE concept is challenged by the military resuscitation model, where ABC is changed to C>ABC. However, this does not require delayed assessment of the airway, which remains the first priority in any trauma situation. 'C' before ABC simply emphasizes that rapid haemorrhage control is a top priority in managing polytrauma patients, allowing prevention of the lethal triad (coagulopathy, hypothermia and acidosis) (Hodgetts et al, 2006). In practice this introduced measures which help clinicians to promptly diagnose and stop the haemorrhage. Compression helps to control bleeding and can be achieved via a pelvic binder, lower/upper limb tourniquet, splinting or padding with bandage (American College of Surgeons, 2008).

Multidetector computed tomography, which is traditionally used as an adjunct to a secondary survey, has become a part of the primary survey. This has been brought up a level in trauma injury recognition (see below), allowing quicker diagnosis and definitive treatment (American College of Surgeons, 2008; Chan, 2009; Saltzherr et al, 2012). However, use of multidetector computed tomography in the primary survey may not be applicable in the civilian trauma setting, as this approach requires the resuscitation room, multidetector computed tomography, interventional radiology suite and theatre to be located in the same area or room. Following immediate intubation even a hypotensive patient can receive multidetector computed tomography and subsequently undergo laparotomy or thoracotomy without the need for further transfer. In contrast, the civilian resuscitation area is often located far from the radiology department and operating room, meaning that only patients who are haemodynamically stable can be safely transferred for further imaging during the secondary survey (American College of Surgeons, 2008).

### Imaging

In most circumstances, patients require imaging to aid clinical diagnosis. Currently, level one trauma centres provide a multidetector computed tomography scan which allows a full body scan of the trauma victim within 5 seconds (Chan, 2009). Multidetector computed tomography has been an essential part of trauma assessment for some time, as it allows rapid radiological and clinical evaluation of the trauma patient and helps to

decide whether he/she requires intensive care unit admission, laparotomy or thoracotomy, or interventional radiology procedures.

Traditional trauma X-ray series and focused assessment with sonography for trauma (FAST) scans are still useful adjuncts. FAST is a rapid, non-invasive and repeatable examination, which is also used in the pre-hospital phase (Chan, 2009; Harris et al, 2012). It can be applied to any major body compartment including the chest (pericardium), abdomen and pelvis (Harris et al, 2012), and can be life saving when, for example, cardiac tamponade is diagnosed within seconds of FAST application (American College of Surgeons, 2008). Unfortunately, there are a few limitations. Although FAST is specific for the presence of free fluid, it is insensitive for the site of blood loss (Harris et al, 2012). Another disadvantage is operator dependence. Also, FAST does not provide any information on the retroperitoneal structures (American College of Surgeons, 2008). More importantly, even if used with standard trauma series X-rays it often fails to identify underlying injuries and can lead to a delay in delivery of definitive treatment.

There are several guidelines and algorithms on the management of trauma-related haemorrhage, which seem to agree that patients who are in haemorrhagic shock, with or without penetrating trauma, should undergo immediate surgery or interventional radiology to stop the haemorrhage (Hilbert et al, 2007; Rossaint et al, 2010; Young and Calland, 2011). In contrast trauma patients who are haemodynamically stable, but with a suspected bleed or a high-risk mechanism of injury, should be investigated further with computed tomography. However, clinicians should ultimately should make these decisions based on the individual patient.

### Immediate control of bleeding

Based on the mechanism of injury and haemodynamic parameters, once major bleeding has been identified it should be controlled as soon as possible. External bleeding is usually obvious and can be effectively addressed by direct pressure or tourniquet if appropriate, bearing in mind that prolonged use of a tourniquet can be potentially harmful, leading to the injury of muscles, nerves and even limb loss as a result of ischaemia (Doyle and Taillac, 2008). Basic principles of tourniquet use include proximal placement to the bleeding site, minimal but high enough pressure to obliterate arterial inflow and maximum time of application of 2 hours (Kragh et al, 2011). Other temporary measures which can be used in the emergency department include an inflated blood pressure cuff applied proximal to a wound to control bleeding, simple padding with a bandage or splinting of the extremity (American College of Surgeons, 2008).

Non-compressible haemorrhage into the chest, abdomen, pelvis or large muscle groups can often be difficult to treat. These patients require immediate decisions regarding resuscitative and operative management. For

example anterior posterior compression type pelvic injuries can be managed initially with application of the pelvic binder in the emergency department as a part of resuscitation, but the next step is surgery to stabilize the pelvis (Nunn et al, 2007).

## Secondary survey

Once the primary survey is completed the patient is constantly reassessed and, if his/her clinical condition permits, the secondary survey (head to toe evaluation) is performed.

This includes a brief history using the AMPLE mnemonic and detailed physical examination to confirm or exclude other injuries (American College of Surgeons, 2008). AMPLE comprises: Allergies, Medications, Past illness and pregnancy, Last meal and Events related to injury. Physical examination follows a logical pattern beginning with the head (including the maxillofacial area), cervical spine with neck, chest, abdomen, perineum, rectum and vagina, followed by musculoskeletal assessment culminating in a full neurological examination.

Depending on the clinical context various diagnostic tests can also be performed, including specific X-rays, computed tomography, urography, transthoracic and transoesophageal echocardiograms, upper gastrointestinal endoscopy and bronchoscopy (American College of Surgeons, 2008).

## Tissue perfusion markers

Resuscitation aims to optimize oxygen delivery to the tissues, and success in restoring this balance can be assessed by haemodynamic parameters (see below) and several markers (lactic acid and base deficit). These surrogates help to recognize hypoperfusion, but none delivers a clear cut-off point. Therefore, they should be interpreted together and on an individual case basis.

Lactic acid and base deficit are the most frequently used markers in the emergency department. In hypovolaemic shock cells are oxygen starved, resulting in anaerobic respiration, which leads to lactic acid formation (American College of Surgeons, 2008). However, lactic acid levels should always be interpreted within the clinical context for a number of reasons. First, raised lactic acid levels may be caused by pre-injury increased activity such as exercise (Harris et al, 2012). On the other hand, reduced or normal levels can be observed in a patient with a severely traumatized ischaemic limb where lack of tissue perfusion gives a falsely low result (Harris et al, 2012). Finally, ongoing resuscitation leading to restoration of perfusion can contribute to rising lactic acid levels.

Several studies have shown that clearance of lactic acid within 24 hours post injury strongly correlates with better survival and measurement of lactic acid can help to guide the resuscitation (Blow et al, 1999; Crowl et al, 2000; Lee and Peitzman, 2006). Base deficit is a better predictor of mortality in patients with haemorrhagic shock than pH in arterial blood gas measurements (Rossaint et al, 2010).

## Haemodynamic parameters

Isolated readings of parameters such as heart rate, blood pressure, skin colour, temperature, mental status and urine output add little value (American College of Surgeons, 2008). Their only role is that trends in their movement give a better idea of the patient's status and response to treatment (Nunez et al, 2010).

Unfortunately, recognition of haemorrhagic shock may not be easy. Young patients can tolerate major blood loss without significant changes in haemodynamic parameters. Ley et al (2009) found that up to 44% of trauma victims can have relative bradycardia (heart rate <90/min) after trauma-related hypotension (systolic blood pressure <90 mmHg). Therefore, various scoring systems have been developed, which combine different parameters, to help with recognition and management of the haemorrhaging trauma patient.

The scores include the shock index, the rate over pressure evaluation (ROPE) and the ABC score (assessment of blood consumption). Shock index (heart rate/systolic blood pressure) has been found to be the best in predicting trauma mortality and ROPE score (heart rate/systolic blood pressure-diastolic blood pressure) predicts development of hypovolaemic shock (Ardagh et al, 2001; Ley et al, 2009; Duchesne et al, 2010). The ABC score is based on four parameters: penetrating mechanisms, positive FAST scan, systolic blood pressure <90 mmHg and heart rate >120/minute, and is the best predictor for a massive transfusion requirement (Duchesne et al, 2010).

Unfortunately, none of these scoring systems provide an ideal trigger score, which would allow rapid identification and treatment of bleeding, and their use is limited in an acute setting with a rapidly deteriorating patient. Therefore, identification and subsequent management of haemorrhage must be a matter of clinical judgement.

## Conclusions

Haemorrhaging polytrauma victims are the most vulnerable group of patients. Their survival depends on prompt haemorrhage recognition and appropriate resuscitation. All interventions should aim to reduce tissue hypoperfusion and restore the physiological balance to ensure optimal outcome. **BJHM**

*Conflict of interest: none.*

## KEY POINTS

- Trauma patients can compensate the haemorrhaging shock with no change in the haemodynamic parameters for a considerable amount of time.
- Mechanism of injury provides invaluable information, which helps to predict possible bony, visceral, soft tissue and vascular injuries.
- Survival of the trauma victim depends on prompt haemorrhage recognition and appropriate resuscitation.

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