13

THE PATIENT WITH MULTIPLE INJURIES

- Traumatic injury is the leading cause of death <40 years of age and the third leading cause overall.
- Traumatic injury is a common cause of admission to ICU – 16% of patients in one study.[1]
- Many patients are intoxicated.
- Injuries are often multisystem in nature.
- For head injuries, see Chapter 19.
- Chest injury is a common reason for the patient requiring prolonged IPPV and, therefore, chest injuries are discussed fully below.

Deaths from trauma follow a trimodal distribution

- Immediate deaths during in the first minutes at the scene are either due to massive haemorrhage or crush injuries, massive CNS trauma or (potentially avoidable) airway obstruction.
- Early deaths during the 'Golden hour' (see Chapter 2) are often due to the effects of haemorrhage or hypoxia and may be preventable
- Late deaths are chiefly due to sepsis and organ failure. Many may be preventable by prompt recognition of injuries and their physiological significance and definitive intervention.

DIFFERENCES BETWEEN HAEMORRHAGIC SHOCK AND TRAUMATIC SHOCK

Haemorrhage results in well-known physiologic changes. Traumatic shock includes these responses but they are modified by the tissue injury and its associated inflammatory response. This has several practical effects:

- Heart rate (HR) responds to haemorrhage by an initial tachycardia followed eventually by a progressive bradycardia.[2] This has been labelled as a 'paradoxical bradycardia' but there is nothing paradoxical about the heart slowing in the absence of adequate venous return in an attempt to maintain stroke volume. This *is* seen following, for example, ruptured ectopic pregnancy. With tissue injury there is no late slowing of the heart and tachycardia continues.
- Blood pressure is maintained by vasoconstriction until more than one-third of blood volume has been lost. With tissue injury, blood pressure is maintained to a greater degree by the surge in catecholamines and other nociceptive stimuli, but this is at the expense of tissue perfusion due to the excessive vasoconstriction.
- Animal studies show that, for an equivalent degree of blood loss, traumatic injury results in greater tissue hypoperfusion and a greater 'injury' than simple haemorrhage.
- The wound and fracture sites are metabolically active with a resultant requirement for increased oxygen consumption and glucose oxidation – the concept of 'the wound as an organ'.[3] In addition to the local reasons for increased metabolic demands, there are systemic inflammatory and catabolic causes of increased metabolic demand requiring an increased cardiac output compared with normal. This may have implications for therapy.

ASSESSMENT OF THE TRAUMA PATIENT

- A system for evaluation of trauma victims results in faster, more effective resuscitation, fewer life-threatening injuries missed and a greater appreciation of priorities.
- The Advanced Trauma Life Support system, as promoted by the American College of Surgeons since 1979, is one such system that has gained widespread acceptance.

- Assessment, diagnosis and initial treatment should be carried out simultaneously.
- This is facilitated by a team approach with a ‘team leader’.
- The patient needs to be completely undressed and examined thoroughly as blunt, high-velocity injury can result in injury to virtually any part of the body.
- The first priorities are to detect and treat immediately life-threatening conditions while second priorities are to detect other injuries (none should be missed).
- Radiological investigations should not take priority over resuscitation.
- Relevant senior specialists should be involved at an early stage.
- Someone experienced should evaluate the abdomen. Peritoneal lavage may be performed where doubt exists regarding the presence of an intra-abdominal injury. Abdominal ultrasound or CT scanning have their advocates.
- Do not forget to administer appropriate antibiotics and tetanus toxoid.
- All dislocations and fractures should be splinted and reduced if possible. This eases nursing, reduces pain and bleeding, and may reduce the incidence of ARDS (see below).

RESUSCITATION

The ABC system is widely followed:

- A = airway including cervical spine protection;
- B = breathing;
- C = circulation;
- D = disability/neurological assessment including GCS;
- E = exposure – undress completely.

The less well-known system of VIP (ventilation, infusion and perfusion) is perhaps more appropriate for trauma patients[4] as it emphasizes the inter-relationship between ventilation and perfusion in overall oxygen transport and because it reminds us that the cornerstone of resuscitation of victims of traumatic injury is fluid infusion.

Airway and cervical spine protection[5]

- The airway *must* be clear or permanent neurological damage or death may occur in minutes.
- The cervical spine should be assumed to be at risk and protected from further damage until proven by radiological screening to be intact. A hard cervical collar is mandatory.
- Unless immediate intubation is required the cervical spine should be assessed by adequate radiological views of all seven cervical vertebrae. One should look for:
  - normal soft tissue shadows;
  - normal vertebral alignment; and
  - normal cervical lordosis.
- If intubation is required, the technique of choice is preoxygenation followed by oral intubation with manual in-line stabilization of the cervical spine by an assistant. Cricoid pressure to reduce the risk of aspiration of stomach contents should be performed.
- It is difficult to find good evidence that this technique, properly performed, has resulted in *additional* neurological impairment in any trauma patient with cervical spine injury. Neurological signs should be documented before intubation, if possible.
- Alternative approaches are impractical or associated with increased complications, e.g.:

Fibreoptic awake intubation	**nasal intubation;**
unfamiliar technique for most practitioners uncooperative or obtunded patient	increased failure rate; epistaxis; bacteraemia; potentially greater C spine movement.

- If the patient cannot be intubated then a surgical airway should be created, i.e. cricothrotomy.

Breathing/ventilation

- High flow O_2 should be administered to all patients.
- Clinically obvious pneumothoraces should be drained.

- There should be an extremely low threshold for immediate tracheal intubation on clinical grounds – even before the result of arterial blood gases.
- Indications for immediate intubation and ventilation include gross respiratory distress, obvious hypoventilation and severe shock.
- Delayed ventilation by promoting tissue hypoxia results in an increased incidence of organ failures.

Circulation

- External haemorrhage must be controlled.
- Large bore catheters (X2) are inserted and volume infused.
- All multiple-injured patients should have large volumes of warmed i.v. fluids, administered quickly.
- One is far more likely to run into problems of inadequate infusion than problems of excess infusion.
- As soon as possible, blood should be sent for blood gas analysis and cross-matching.

Infusion

- The choice of fluid is controversial. For the 'colloid/crystalloid' debate, see Chapter 4. However, what *can* be stated with certainty is that multiple-trauma patients will almost certainly require the transfusion of blood.
- Crystalloid solution (2 litres) or colloid (1 litre) should be administered as rapidly as possible in any multiple-injured patient followed by further fluids including blood as indicated.
- Be prepared to give type-specific but uncross-matched blood or O-negative blood *in extremis*.
- Many junior doctors do not appreciate the magnitude of concealed blood loss from closed orthopaedic injuries, e.g. 2 litres from a femoral shaft fracture and potential exsanguination from a bad pelvic fracture.
- In all but the most desperate situations, the skin should be appropriately prepared prior to venous cannulation as the leading cause of late death in trauma patients is sepsis.
- In cases of massive blood loss and transfusion, maintenance of coagulation must be addressed and infusions of FFP and platelets given as indicated by results of coagulation screens.

Permissive hypovolaemia

- An important study in 1994 of penetrating trauma showed an improved survival in those patients with 'delayed' fluid resuscitation, i.e. minimal i.v. fluids given prior to definitive operative intervention.[6] This has been called 'permissive hypovolaemia'.
- The rationale, suggested by previous animal studies, is that full resuscitation results in:
  - a higher BP disrupting clot formation;
  - haemodilution and decreased viscosity disrupt clot formation;
  - dilutional coagulopathy.
- The recommendation has, therefore, been made to limit fluids to maintain a MAP $\leq$ 50 until bleeding has been surgically controlled, *then* proceed to full resuscitation.
- The problems limiting widespread acceptance of this concept are:
  - the need for *prompt* definitive intervention to minimize the oxygen debt;
  - delays in surgery, e.g. in rural area may be better with 'normal' resuscitation;
  - this approach is inappropriate for patients who also have head injury.
- The biggest problem is that this study was performed in *penetrating* injuries. Patients with blunt trauma (the majority) are not so likely to have definitive surgical interventions.

Differences between blunt and penetrating trauma

Penetrating:

- Common in the USA.
- Often sole injury.
- Diagnosis often simple.
- Surgery often definitive treatment.

Blunt:

- More common in Europe.
- Not usually in isolation.
- Diagnosis often complex.

- Surgery rarely definitive.
- Therefore, this approach is not recommended in patients suffering blunt trauma.
- Further controlled trials are awaited but it would be unfortunate if improvements in trauma management related to an understanding of the importance of rapid resuscitation (the 'Golden hour' concept) with volume infusion as a cornerstone of that resuscitation were lost because fluid restriction was seen as appropriate in any but a few specific (and uncommon) circumstances.

Perfusion

- The overall goal of all resuscitation procedures is to improve oxygenation and perfusion of body tissues.
- Oxygen therapy and maintenance of blood volume and oxygen-carrying capacity is usually sufficient to restore homeostasis in the majority of trauma victims.
- It is worth remembering that even in the young patient cardiac function can be severely compromised in haemorrhagic shock so that an element of cardiogenic shock contributes to the shocked state. In such cases the response to resuscitation may be compromised and invasive monitoring and/or inotropes required as detailed below.
- As early as the 1950s the contribution of the heart to progressive, irreversible shock was recognized and it was also demonstrated that the homeostatic mechanisms and vasoconstriction were not sufficient to maintain coronary perfusion in severe haemorrhage.
- Therefore, cardiac dysfunction needs to be detected and corrected as early after injury as possible.

Goals of resuscitation

- In most uncomplicated cases where resuscitation has been rapid the goals of resuscitation are:

Increase:

- BP
- Urine output
- Capillary perfusion
- Conscious level

Decrease:

- HR

- Temperature
- Increases in urine output and conscious level are assumed to reflect increased organ perfusion overall.
- Invasive haemodynamic monitoring with a pulmonary artery catheter is not required in most patients.
- However, *all* patients who do not respond promptly to oxygenation and volume resuscitation with or without surgery should be invasively monitored to guide optimal fluid therapy and detect cardiac dysfunction.
- The threshold for invasive monitoring should be lower in the elderly patient and those with existing disease states.

The rationale for a low threshold for invasive monitoring is as follows:

Problems of inadequate cardiac output and occult shock

One study in the elderly[7] emphasized the importance of early detection of cardiac dysfunction by invasive monitoring using a PAFC. Elderly trauma patients who had low cardiac output who were on average monitored 5.5 h after injury had an overall survival of only 7% – the rest dying of cardiogenic shock and multiple organ failure. Thirty similar elderly patients were then studied. These patients were monitored much earlier – in a mean time of 2.2 h. Low cardiac outputs were detected, inotropic support provided and the overall survival in this second similar group was 53%. The message is clear:

- Elderly trauma patients may have dangerously low cardiac output unrecognized by non-invasive monitoring. If this is left untreated cardiogenic shock and organ failure may supervene. It is interesting to compare the results of this study with the largely empirical idea of the 'Golden hour'.
- Further studies on younger patients have shown similar results with similar conclusions.[8]

Problems with BP and HR as indices of resuscitation

Fluid therapy regimens have been promoted relying on changes in HR and blood pressure (BP) to guide fluid requirements. This is not an adequate approach for all patients. Heart rate and MAP are affected by the degree of tissue trauma as well as the degree of hypovolaemia.[2] In addition, studies show[9] poor correlation between MAP and CI:

- HR and changes in HR poorly correlate with CI.
- MAP and CI only correlated well at initial measurement and preterminally.

- By the time hypovolaemia and low CI are of sufficient magnitude to produce hypotension their correlation is greatly improved, but by this time the deteriorating circulating condition is well advanced. Therefore, reliance on hypotension as an early warning sign of shock or reliance on a normal BP as a measure of adequate fluid resuscitation or tissue perfusion may be unwarranted.

Indices of adequate resuscitation

The goals of resuscitation in complicated or prolonged resuscitations include:

- Optimal CI with optimal PCWP.
- Normal lactate and base deficit (BD). The time needed to normalize serum lactate levels is an important prognostic factor for survival in the severely injured patient. BD correlates well with degree of injury, magnitude of blood loss and outcome.[10] In a laboratory model, the BD was superior to any other measurable parameter in identifying degree of haemorrhage.[11]
- Supranormal oxygen transport goals. While there is doubt about the general applicability of attempting to achieve 'supranormal' CI, DO_2 and VO_2 in all ICU patients, there is still convincing evidence for their usefulness in traumatic injury. For example:
  - reaching supranormal circulatory values, especially in 24 h of injury, may improve survival and reduce the frequency of shock-related organ failure in the severely traumatized patient;[12] and
  - increased CI, DO_2, and VO_2 seen in survivors of severe trauma are primary compensations that have survival value; augmentation of these compensations compared with conventional therapy decreases mortality.[13]

  Possible reasons for the value of this approach include the concept of 'the wound as an organ'.

  Only one major study has failed to find evidence of benefit from achieving supranormal goals.[14]
- pHi. This may be an important marker to assess the adequacy of resuscitation. pHi monitoring may provide early warning for systemic complications in the postresuscitation period.[15]

Operative intervention

- Many trauma patients will need surgery.

- In general, all the required surgical procedures should be performed acutely, i.e. during one anaesthetic providing the patient has been appropriately resuscitated and is haemodynamically stable.
- The rationale is that once the patient is resuscitated, they will be in the best condition that s/he will be in for some time, i.e. before the development of sepsis, tissue oedema, malnutrition and metabolic complications.
- Delayed fixation of long bone fractures may increase the incidence of ARDS.[16] The mechanisms are uncertain but will probably include ongoing bleeding, increased pain, and physiological stress response and possible fat embolus.
- Conversely if the patient undergoing surgery *is* unstable with developing hypothermia, coagulopathy and acidosis, prolonged surgery has a high mortality rate. Many surgeons now accept that the best way to manage these patients is to 'bail out', e.g. pack the abdomen to stop bleeding, bring out bowel the ends on to the abdominal wall, etc., and to take the patient to ICU for stabilization and further resuscitation. Further surgical intervention is deferred to a later date. This has been described as 'damage control surgery'.[17]

Chest injuries

Immediate management:

- Ensure a patent airway.
- Administer oxygen.
- Exclude:
  - pneumothorax;
  - haemothorax;
  - cardiac tamponade.
- Emergency management of tension pneumothorax with either severe respiratory embarrassment or circulatory collapse is with a 14G i.v. cannula inserted anteriorly through the second intercostal space. More formal drainage is by wide-bore chest drain tube inserted with a sterile technique. Insertion should be under direct vision after dissection down to the pleura. Most physicians recommend inserting the tube in the mid-axillary line at the level of the nipple. The tube should be directed posteriorly especially in the presence of a haemothorax.

- The classic signs of cardiac tamponade include a falling BP and a rising JVP but these signs may be mimicked by a tension pneumothorax. Aspiration of as little as 30 ml pericardial fluid via a xiphisternal approach may produce considerable (but short lived) improvements in haemodynamics. Further surgical definitive care will be necessary.

Penetrating chest injuries

Penetrating chest injuries *all* require surgery, preferably in a specialist centre. However, penetrating cardiac injuries do not normally tolerate the delays associated with interhospital transfer. Emergency room thoracotomy for penetrating cardiac injuries carries a surprisingly good prognosis.[18]

Massive haemothorax

Immediate thoracotomy is indicated according to many chest surgeons if the initial bleed is >1500 ml on insertion of the chest drain or if there is continual drainage after insertion of the chest drain. In theory (and usually in practice) re-expansion of the lung following drainage 'tamponades' the bleeding.

Pain relief

Adequate pain relief is a crucial part of treatment of patients with chest injuries. Acutely, i.v. narcotics should be titrated according to effect. Later there are many suitable techniques largely chosen according to individual preference:

- PCA;
- i.v. infusion of narcotics;
- thoracic epidural is probably the regional anaesthetic technique of choice and has been shown, for example, to be superior to intrapleural catheter;[19]
- non-steriodal anti-inflammatory drugs (NSAIDS) are useful adjuncts especially for simple rib fractures.

Reconsider IPPV

- After acute resuscitation one may have to reconsider the necessity for ventilation.
- In general, this will be dependant on the degree of pulmonary contusion or collapse and the increased work of breathing.

- The overall condition of the patient also has an influence, e.g. a low threshold for IPPV in the presence of other injuries especially head injury, pre-existing chest disease or the elderly patient.

Myocardial contusion

Unexpected arrhythmias are often a clue to the presence of myocardial contusion. Electrocardiogram (ECG) and cardiac enzyme changes are variable and may mimic a myocardial infarction (MI). Treatment is syptomatic and recovery is common unless gross cardiac failure is present.

Pulmonary contusion

- There may be few signs and symptoms in the early period after injury. In addition, an initial CXR may also be normal.
- However, bruised lung like any other bruised tissue becomes more oedematous with time, i.e. pulmonary function will deteriorate over 48 h and IPPV may become necessary.
- 'Avoid over hydration' is good advice but the choice of fluid and the end points of fluid therapy are difficult and controversial.
- There is a high incidence of associated injury especially head and abdominal injuries.

Rib fractures

- There is no specific treatment for rib fractures.
- One should note, however, that first rib fractures are especially serious due to the large force required to cause them to fracture. Thus, there is a high incidence of associated injuries especially mediastinal and brachial plexus injuries.
- Similarly, lower rib fractures are associated with a high incidence of liver and spleen injuries depending on the side fractures are on.
- Elderly rib cages have usually lost their elastic recoil and therefore even injuries with low kinetic energy cause significant fractures. Conversely, the rib cages of the young patient transmit the kinetic energy more readily and can result in significant life-threatening contusion in the absence of rib fractures.

Flail chest

- Flail chest is a functional diagnosis and not a radiological diagnosis.
- The physiological effects are due to four main problems:
  - underlying contusion;
  - impaired elastic recoil leading to pulmonary collapse;
  - increased work of breathing;
  - pain leading to sputum retention.
- The approach varies according to the severity of the chest injury, the severity of associated injuries and the effectiveness of pain relief.
- The best single guide to the requirement for IPPV is the degree of pulmonary contusion.[20]
- Management is either conservative or invasive.

Conservative

- Includes oxygen therapy, adequate analgesia, especially epidural analgesia, and physiotherapy.
- Is indicated in an isolated injury with adequate gas exchange and a good cough.
- Prophylactic IPPV for such patients may increase complications and prolong hospital stay.

Invasive

- The presence of significant contusion, pre-existing chest disease, other significant injuries or an ineffective cough are indications for IPPV.
- Up to 69% of patients with flail chest require mechanical ventilation for an average of 22 days.[21]
- Surgical fixation of the flail segment in the absence of any other indications for thoracotomy is controversial and unproved.

Outcome after multiple injury

- Patients admitted to ICU following multiple injuries often have a protracted length of stay, duration of IPPV and consume a lot of resources.[22]
- Isolated pulmonary contusion in young trauma patients has a good prognosis.[23]

- Length of stay and mortality are increased in the elderly trauma patient with a greater proportion requiring chronic care following discharge from ICU.
- Development of sepsis and multiple organ failure is responsible for much of the late mortality.
- Young trauma patients have a better prognosis and for those who survive they have a good prospect of rehabilitation and a fairly good ultimate outcome.

Further reading

Nolan JP, Parr MJA. Aspects of resuscitation in trauma. *Br J Anaesth* 1997: **79**; 226–40.

Santora TA, Schinco MA, Trooskin SZ. Management of trauma in the elderly patient. *Surg Clin North Am* 1994: **74**; 163–86.

Moore FA, Moore EE. Evolving concepts in the pathogenesis of postinjury multiple organ failure. *Surg Clin North Am* 1995: **75**; 257–77.

Falk JL, O'Brien JF, Kerr R. Fluid resuscitation in traumatic hemorrhagic shock. *Crit Care Clin* 1992: **8**; 323–40.

References

1. Loes O, Smith Erichsen N, Lind B. Intensive care: cost and benefit. *Acta Anaesthesiol Scand* 1987: **31 (suppl.)**; 84–9.
2. Little RA. 1988 Fitts Lecture: Heart rate changes after haemorrhage and injury – a reappraisal. *J Trauma* 1989: **29**; 903–6.
3. Wilmore DW. The wound as an organ. In Little RA, Frayn KN (eds), *The Scientific Basis for the Care of the Critically Ill*. Manchester University Press, 1986.
4. Weil MH, Shubin H. The 'VIP' approach to the bedside management of shock. *JAMA* 1969: **207**; 337–40.
5. Wood PR, Lawler PG. Managing the airway in cervical spine injury. A review of the Advanced Trauma Life Support protocol. *Anaesthesia* 1992: **47**; 792–7.
6. Bickell WH, Wall MJ Jr, Pepe PE *et al*. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *N Engl J Med* 1994: **331**; 1105–9.
7. Scalea TM, Simon HM, Duncan AO *et al*. Geriatric blunt multiple trauma: improved survival with early invasive monitoring. *J Trauma* 1990: **30**; 129–34.

8. Abou-Khalil B, Scalea TM, Trooskin SZ *et al*. Hemodynamic responses to shock in young trauma patients: need for invasive monitoring. *Crit Care Med* 1994: **22**; 633–9.

9. Wo CC, Shoemaker WC, Appel PL *et al*. Unreliability of blood pressure and heart rate to evaluate cardiac output in emergency resuscitation and critical illness. *Crit Care Med* 1993: **21**; 218–23.

10. Rutherford EJ, Morris JA Jr, Reed GW, Hall KS. Base deficit stratifies mortality and determines therapy. *J Trauma* 1992: **33**; 417–23.

11. Waisman Y, Eichacker PQ, Banks SM *et al*. Acute hemorrhage in dogs: construction and validation of models to quantify blood loss. *J Appl Physiol* 1993: **74**; 510–19.

12. Bishop MH, Shoemaker WC, Appel PL *et al*. Relationship between supranormal circulatory values, time delays, and outcome in severely traumatized patients. *Crit Care Med* 1993: **21**; 56–63.

13. Bishop MH, Shoemaker WC, Appel PL *et al*. Prospective, randomized trial of survivor values of cardiac index, oxygen delivery, and oxygen consumption as resuscitation endpoints in severe trauma. *J Trauma* 1995: **38**; 780–7.

14. Durham R, Neunaber K, Mazuski J *et al*. The use of oxygen consumption and delivery as endpoints for resuscitation in critically ill patients. *J Trauma* 1996: **41**; 32–40.

15. Ivatury RR, Simon RJ, Havriliak D *et al*. Gastric mucosal pH and oxygen delivery and oxygen consumption indices in the assessment of adequacy of resuscitation after trauma: a prospective, randomized study. *J Trauma* 1995: **39**; 128–34.

16. Johnson KD, Cadambi A, Seibert GB. Incidence of adult respiratory distress syndrome in patients with multiple musculoskeletal injuries: effect of early operative stabilization of fractures. *J Trauma* 1985: **25**; 375–84.

17. Hirshberg A, Mattox KL. 'Damage control' in trauma surgery. *Br J Surg* 1993: **80**; 1501–2.

18. Arreola-Risa C, Rhee P, Boyle EM *et al*. Factors influencing outcome in stab wounds of the heart. *Am J Surg* 1995: **169**; 553–6.

19. Luchette FA, Radafshar SM, Kaiser R *et al*. Prospective evaluation of epidural versus intrapleural catheters for analgesia in chest wall trauma. *J Trauma* 1994: **36**: 865–9.

20. Ciraulo DL, Elliott D, Mitchell KA, Rodriguez A. Flail chest as a marker for significant injuries. *J Am Coll Surg* 1994: **178**; 466–70.

21. Wisner DH A stepwise logistic regression analysis of factors affecting morbidity and mortality after thoracic trauma: effect of epidural analgesia. *J Trauma* 1990: **30**; 799–804.

22. Goins WA, Reynolds HN, Nyanjom D, Dunham CM. Outcome following prolonged intensive care unit stay in multiple trauma patients. *Crit Care Med* 1991: **19**; 339–45.

23. Hoff SJ, Shotts SD, Eddy VA, Morris JA Jr. Outcome of isolated pulmonary contusion in blunt trauma patients. *Ann Surg* 1994: **60**; 138–42.