Paediatric trauma

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Abstract

Injury is the commonest cause of death amongst children over the age of 1 year in the developed world. Injury patterns vary across the world. In the UK, paediatric trauma is relatively rare and mainly from blunt injuries. Importantly, the majority of severely injured children are under 10, and more than 25% are less than 1 year of age.

Children are anatomically and physically different from adults and their trauma patterns, response and management are also different from those of adults. The evidence shows that children have a better outcome from management under specialist paediatric care.

This article covers the principles of trauma management including differences between adult and paediatric management such as volume resuscitation, paediatric trauma imaging and the non-operative approach to solid organ injuries.

Keywords Non-operative management; paediatric trauma

Introduction

Injury is the commonest cause of death amongst children over the age of 1 year in the developed world. The long-term burden of disability to affected individuals and families is significant but difficult to actually measure. Importantly the majority of severe injuries (Injury Severity Score (ISS) >15) occur not in teenagers but in children under the age of 10, over 25% in under-1-year-olds.[1]

Injury patterns vary across the world. In the UK paediatric trauma is relatively rare, the majority being sustained from blunt injuries: motor vehicle accidents (MVA) 40%, and falls 36%. At least 75% of seriously injured children have a significant head injury. Most deaths from paediatric trauma occur on scene the TARNlet report 'Severe Injury in Children 2012' demonstrated that of 233 deaths, only 56 were in hospital).

Penetrating trauma is rare but in North America and Africa it accounts for up to 10% of paediatric trauma. Non-accidental injury (NAI) should always be considered, particularly as this group has a higher injury severity and higher risk of death. NAI patients often present to non-specialist centres with a history that may not necessarily suggest significant trauma such as vague abdominal pain or vomiting.

The majority of developed countries now have specialist trauma units. There are significant differences between paediatric and adult trauma patients and it is imperative that a surgeon has a working knowledge of the investigation and management of paediatric trauma as distinct from adult trauma. Children are not small adults.

Trauma patterns

The ribs in a child are more pliable, the abdominal wall thinner, the diaphragm relatively flat and the liver and spleen comparatively larger. The ribcage is significantly compliant and allows more direct transmission of force to the thoracic and abdominal viscera. Injury to the thoracic cage itself such as rib fractures, flail segments and paradoxical respiration are seldom seen in children but, if present, make visceral injury more likely.

Young children are prone to rapidly developing respiratory embarrassment due to: a relatively small-calibre trachea and bronchi, disproportionately affected by swelling; lower functional residual capacity; and higher oxygen consumption per unit body mass. Even minor chest injury may provoke hypoxia.

The same mechanics of injury bring about different injury patterns in children and adults. Modern cars are designed to reduce the trauma impact on pedestrians struck by the vehicle. In particular this includes bumpers and bonnets designed to reduce impact on the limbs and head of an adult respectively. A small child however will receive the majority of force from the bumper directly to the pelvis and torso with concomitant forced flexion of the head striking the bonnet.

Initial assessment

The outcomes in paediatric trauma are better when children are cared for in paediatric trauma centres by appropriately staffed and trained paediatric trauma teams.[2] This was the basis of the national trauma reorganization in the UK in 2012. Significantly injured paediatric trauma patients should be transferred to specialist trauma centres for both initial and definitive management.

Trauma teams follow a structured approach to trauma management. As with adult resuscitation, the initial aims are control of massive haemorrhage, management of the airway and breathing, immediate diagnosis and treatment of life-threatening chest injuries, supporting the circulation and prevention of the 'trauma triad' of acidosis, hypothermia and coagulopathy if necessary by damage control surgery (see accompanying article in this issue). The initial assessment of the patient is entirely clinical and must specifically exclude five life-threatening chest injuries: tension pneumothorax, massive haemothorax, open chest wound, flail chest and cardiac tamponade. If any of these conditions are identified or suspected they should be empirically treated without further supportive diagnostic tests.

Tension pneumothorax manifests as severe hypoxia, shock, hyper-resonance of the affected hemi-thorax, diminished breath sounds, tracheal deviation to the contralateral side and displacement of cardiac impulse. The clinical reality in major trauma patients is that such signs may be subtle or obscured and if sufficient clinical concern is raised the affected chest should be decompressed by either needle thoracocentesis in the mid-clavicular line above the second rib or by stab thoracotomy. This should be definitively managed with a chest drain. Haemothorax, may be clinically detected by dullness to percussion on the affected side depending on the volume of blood accumulating. The closed chest has a tamponade effect on this and placement of a chest drain should not be undertaken until appropriate circulatory support has been given.

The mechanics of respiration are compromised by an open, penetrating chest injury and similarly by the paradoxical movement of a flail segment of chest wall. Both should be managed by placement of a chest drain, the latter with a three-sided dressing

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over the open wound. Lastly, the accumulation of blood in the pericardial cavity causes haemodynamic compromise by progressively impeding venous return to the heart and should be drained as an emergency if suspected. It is however much rarer in children than adults.

Large-bore venous access must be obtained early in resuscitation, if necessarily utilizing intra-osseous devices. It is important to highlight that paediatric pathophysiology is much more varied than in adults. Small children and infants have faster heart rates and proportionately shorter diastolic filling times thereby coping poorly with fluid depletion. Older children may be able to compensate well in the initial stages of shock but then deteriorate rapidly. Fluid resuscitation and transfusion protocols in children are based on weight, either known or calculated according to formulae for age. Fluid boluses are delivered at 10 ml/kg but appreciating the value of hypotensive resuscitation and early administration of blood and blood products. Despite limited research evidence, consideration should be given to the early administration of tranexamic acid.

The role of resuscitative thoracotomy remains controversial in paediatric trauma patients. Its purpose is allow descending aortic cross-clamping in order to reduce distal bleeding and divert blood to the heart and brain. This is only successful in patients with penetrating trauma who had a pulse on arrival at the emergency department, not in patients already arrested and not for blunt abdominal trauma. There is currently no paediatric experience of the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) via femoral arterial puncture.

Clinical assessment in abdominal trauma

As highlighted in the primary survey and diagnosis of the five life-threatening injuries, initial management of trauma patients relies heavily on clinical examination. This is also borne out in assessment of abdominal injuries. Evidence shows that thorough clinical assessment and examination of trauma patients can identify accurately those trauma patients in whom CT is not required.[3] In this large study the absence of seven clinical signs had a negative predictive value for intra-abdominal injury of 99.9%. The criteria are shown in Box 1. Note that gentle repeated examination is efficacious. There is no indication for per rectal examination as part of routine assessment.

Seriously injured patients require close monitoring of fluid status and there is value in placement of a urinary catheter unless evidence of significant pelvic or urethral injury. Similarly, gastric tube decompression is efficacious; significant respiratory embarrassment by a distended stomach can occur, and it reduces the risk of vomiting. The tube should be passed orally if concern exists about a basal skull fracture.

Imaging

It is important in the imaging of paediatric trauma patients to remember that children are not small adults. Their different trauma patterns, physiology and radio-sensitivity form the foundations of a recent review of evidence-based imaging.[4] Unlike adult imaging, it is inappropriate to scan intervening areas (e.g. neck and chest) simply for ease; 'the pan scan' unnecessarily exposes children to excess doses of radiation.[5] UK specialist recommendations are that CT is the investigation of choice in significant head and abdominal trauma. For non-penetrating thoracic trauma, CXR will exclude the vast majority of chest injuries particularly if accompanied by CT of the abdomen. A single lateral cervical spine view and appropriate clinical examination will exclude the majority of (rare) cervical injuries.

Criteria to exclude intra-abdominal injury by clinical examination alone

If none of the following are present, intra-abdominal injury can be reliably excluded:

- Glasgow Coma Scale score >13
- No evidence of abdominal wall trauma or seat belt sign
- No complaints of abdominal pain
- No abdominal tenderness
- No vomiting
- No thoracic wall trauma
- No decreased breath sounds

Box 1

Abdominal CT has a negative predictive value of significant intra-abdominal injury in 99.6%.[6] It has a high sensitivity for solid organ injury, vascular injury, free air, free fluid, haematoma and active bleeding.

Focused assessment with sonography in trauma (FAST) is not appropriate in paediatric trauma management; it has poor sensitivity and specificity. FAST should neither be used to guide surgical management nor replace CT as a diagnostic modality.[7] Similarly, formal ultrasound examination has very poor sensitivity (66%) in the acute setting, although does have a place in follow-up and the identification of fluid collections secondary to the initial injury such as bile leaks, haematoma or abscess.

Neither plain abdominal radiography nor diagnostic peritoneal lavage (DPL) have a role in paediatric trauma management. Laparoscopy is a useful adjunct in those with experience and in select patients.

The only mandatory blood investigations in a trauma patient are for cross-match. There is little requirement in acute trauma management for basic laboratory investigations: haemoglobin, basic biochemistry and blood glucose will all dramatically change during resuscitation. Baseline liver function tests and amylase are useful for monitoring.

Thoracic trauma

The five, immediately life-threatening injuries in the chest are dealt with in the primary assessment of the patient. The remaining injuries should be discussed with thoracic specialists even if conservative management is indicated.

Rib fractures

Due to significant compliance and flexibility of the rib in young children, fractures are uncommon. Their absence does not exclude significant visceral injury. Existence of fractures in children should raise concern over the possibility of non-accidental injury. Management is principally analgesia and manoeuvres to reduce the risk of atelectasis and subsequent infection.