CHAPTER 1

Introduction

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Trauma is a leading cause of morbidity and mortality in the developed world, accounting for 39 deaths per 100 000 population in the United States in 2005 and around 800 000 deaths per year in Europe. Deaths resulting from trauma typically follow a tri-modal distribution (Figure 1.1). The first peak, which accounts for 50% of all trauma deaths, occurs within the first few minutes after injury. Very few of these victims can be salvaged and thus prevention is the key to significantly decreasing the rate of immediate deaths. The second peak occurs from a few minutes up to several hours after injury, often due to uncontrolled bleeding, and accounts for 30% of trauma-related mortalities. With appropriate medical care many of these patients can be saved by prompt identification and management of correctable injuries. The last peak occurs days to weeks after the injury. Outcome during this period of late deaths depends in part on how cases are managed in the preceding periods.

Recognition that trauma care was previously fragmented and disorganized with poor outcomes has helped to stimulate innovations in trauma care including trained paramedics, advanced trauma life support (ATLS) training for surgeons and in-house response teams in many hospitals. These developments, supported by technological advances including imaging techniques, have led to an improvement in the quality of emergency care. Nevertheless, motor vehicular collisions, domestic and industrial accidents, assaults, gunshot wounds and injuries related to acts of terrorism continue to challenge the management of trauma by medical teams throughout the world.

During the hospital phase of resuscitation, modern technology and medical facilities should complement the physician's clinical skills to improve decision making for trauma patients. There are a number of different imaging modalities that can be used to assist in the management of these patients, each with a variety of strengths and weaknesses. Plain radiographs remain a useful tool, particularly for the assessment of limb fractures and dislocations. In recent years, however, there have been significant developments in the imaging of major trauma, particularly with the introduction of multidetector computed tomography (MDCT), which allows rapid acquisition of detailed whole body cross-sectional imaging. Coupled with advances in post-processing techniques, MDCT now also allows the routine application of computer-generated high-quality multiplaner reformat (MPR) and three-dimensional volume-rendered images in addition to the axial plane images (Figure 1.2). This new technology has redefined the role of plain radiographs, ultrasound and computed tomography in the evaluation of victims of major trauma. At institutions where the full range of diagnostic imaging facilities are readily available, whole body MDCT has become the imaging investigation of choice in stable patients following the initial ATLS recommended trauma series (chest, lateral cervical spine and pelvis). Some trauma centres are also fortunate enough to have CT within the emergency department and are advocating CT for all but the most unstable trauma patients, a policy which is not suitable for many other hospitals where CT facilities are remote from the resuscitation area or may not be immediately available for an unstable trauma patient. In such circumstances and in more austere situations, alternative imaging strategies will need to be employed, including additional plain radiographs, ultrasound, intravenous urography and on-table in-theatre angiography.

Ultrasound has been used in the investigation of abdominal trauma since the 1970s and interest grew in the 1990s with the availability of hand-held ultrasound machines and the development of the limited focused assessment of sonography in trauma (FAST) technique (Figure 1.3). The FAST technique enables non-radiologists with limited training to perform a rapid ultrasound examination in the resuscitation room looking for free intraperitoneal fluid (Figure 1.4) with a reasonable degree of accuracy. FAST can be used to triage a haemodynamically unstable patient with significant free fluid to surgery; however, the absence of free fluid does not exclude a significant intra-abdominal injury requiring surgical intervention. Even in the hands of experienced observers the sensitivity of ultrasound for demonstrating organ lacerations and mesenteric or retroperitoneal injury is poor and thus it cannot be routinely used to exclude injury as a stand-alone technique. Where facilities are limited and no CT is available, a policy of admission for observation and repeat ultrasound by an experienced operator can be used but should not be considered best practice.

Imaging findings in conjunction with clinical assessment can be crucial in providing the critical information required to make key management decisions. Thus, an understanding of current trauma

ABC of Imaging in Trauma. By Leonard J. King and David C. Wherry
Published 2010 by Blackwell Publishing

imaging concepts and their clinical relevance is essential for all medical personnel involved in the immediate hospital care of trauma patients whose outcome may depend on rapid assessment of the nature and severity of their injuries, allowing appropriate medical management and surgical and non-surgical intervention.

Although the precise role of imaging and the choice of modality will vary depending on the clinical scenario and the availability of equipment and local expertise, the fundamental goals remain the same – that is, assisting clinical staff in rapidly identifying the range and severity of injuries in the trauma patient and, where possible, intervening to arrest life-threatening haemorrhage with use of endovascular procedures. It is important for those involved in trauma care to recognize the place of imaging in relation to other clinical activities and how it fits into the clinical algorithm. The ATLS approach in trauma care is summarized in Box 1.1.

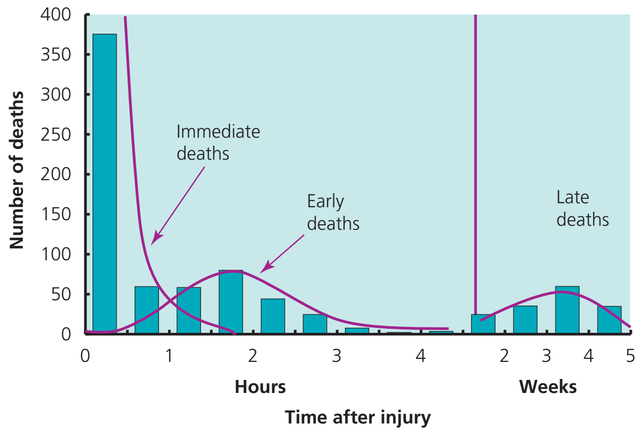
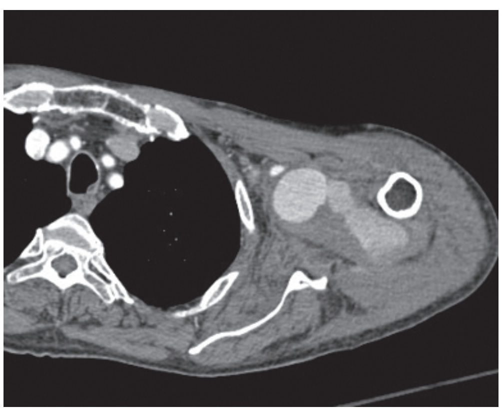


Figure 1.1 Graph illustrating the trimodal distribution of deaths following trauma. Graph taken from the ATLS Manual, 2005. Reproduced with the permission of the American College of Surgeons.

Although there are helpful published criteria for determining the need for cranial and cervical CT scanning following trauma, there are as yet no universally accepted criteria for determining when whole body CT is indicated, and local policies will vary. Most patients are triaged to CT on the basis of mechanism of injury, such as a high-velocity motor vehicle collision, and an initial clinical assessment indicating significant injury, particularly where there is evidence of two or more anatomically remote injuries, for example head injury plus a pelvic fracture or chest injury plus femoral fracture, etc. Whole body CT is also helpful in assessing patients with clinical signs of external trauma in whom the mechanism of injury is unknown, for example a patient found unconscious with bruising, lacerations or an obvious fracture and no available witness statement.

The purpose of this book is to provide a concise and practical guide to the role, performance and interpretation of emergency imaging procedures in patients with major trauma, such as those encountered in road traffic accidents, major disasters such as earthquakes and the victims of civilian or military conflict. The author-

(a)



(b)

(c)

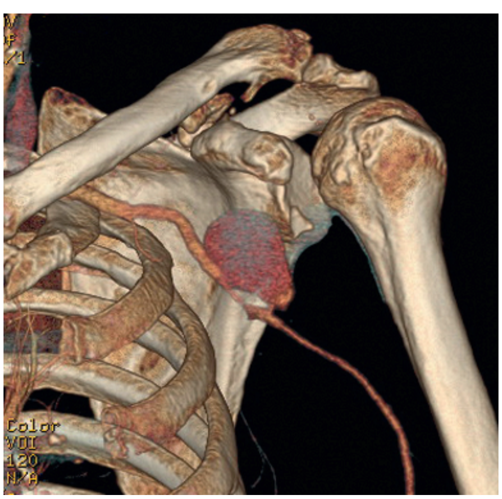


Figure 1.2 (a) Conventional axial images; (b) coronal multiplaner reformat; and (c) 3D volume-rendered CT images of a traumatic axillary artery pseudoaneurysm.

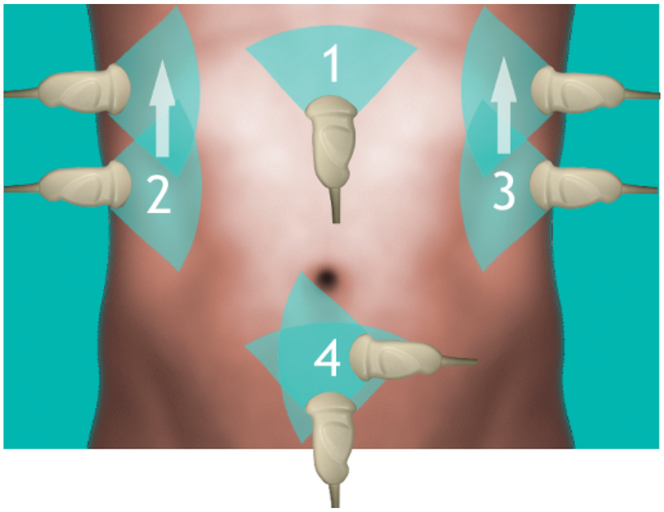


Figure 1.3 Ultrasound probe positions for a limited focused assessment of sonography in trauma ultrasound examination.

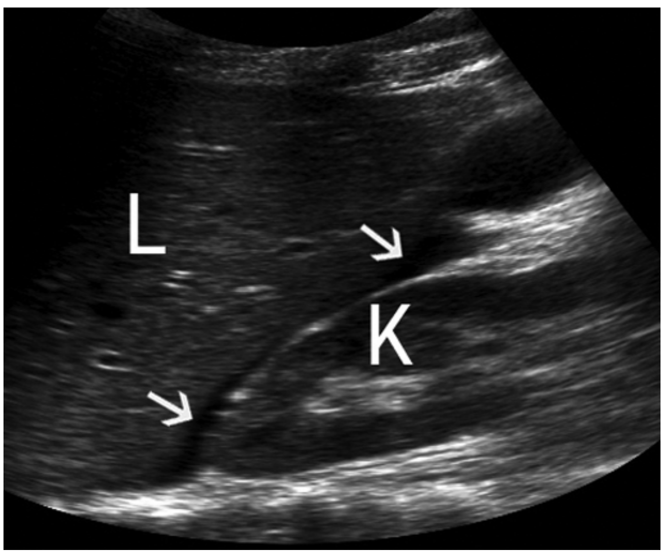


Figure 1.4 Longitudinal ultrasound image of the right upper quadrant demonstrating a small volume of free intraperitoneal fluid (arrows) between the liver (L) and the right kidney (K).

Box 1.1 **ATLS approach in trauma care**

A Primary survey and assessment of ABCDEs
- 1 Airway with cervical spine protection
- 2 Breathing
- 3 Circulation with control of haemorrhage
- 4 Disability: brief neurologic evaluation
- 5 Exposure/Environment: undress patient and prevent hypothermia

B Resuscitation
- 1 Oxygenation and ventilation
- 2 Shock management – IV fluids
- 3 Management of life-threatening problems identified in the primary survey

C Adjuncts to primary survey and resuscitation
- 1 Monitoring
  - a Arterial blood gases
  - b Ventilation
  - c End tidal CO_2
  - d Electrocardiogram
  - e Pulse oximetry
  - f Blood pressure
- 2 Urinary catheter and nasogastric tube placement
- 3 Radiographic and other diagnostic studies
  - a Chest x-ray
  - b Pelvis x-ray
  - c Cervical spine x-ray (lateral)
  - d FAST or DPL

D Secondary survey: total patient evaluation
- 1 Head and skull
- 2 Maxillofacial and intra-oral
- 3 Neck
- 4 Chest
- 5 Abdomen (including back)
- 6 Perineum/rectum/vagina
- 7 Extremities

E Adjuncts to the secondary survey (performed after life-threatening injuries have been identified and managed)
- 1 Computed tomography
- 2 Contrast studies
- 3 Extremity radiographs
- 4 Endoscopy and ultrasonography

F Definitive care

ship draws on a large number of experienced radiologists and surgeons who manage trauma in their daily practice, both in civilian and military settings. The boundaries of these two seemingly separate spheres are becoming increasingly blurred. Civilian casualties from ballistic trauma and acts of terrorism are frequently encountered in cities throughout the world and lessons learned from medical care in military conflict have relevance in rural, urban and suburban non-military settings.