Trauma radiology in the UK: an overview

ABSTRACT

NHS Choices defines 'major trauma' as multiple, serious injuries that could result in disability or death. Worldwide, trauma is the leading cause of death and disability in people under 40 years of age. The National Audit Office estimates that there are at least 20 000 major trauma cases in England every year, resulting in 5400 deaths and leaving many others with serious permanent disability. Because the incidence of trauma is particularly high in younger patients, an average of 36 life years is lost for every trauma death (Chaira and Cimbanassi, 2003).

The landscape in major trauma imaging has evolved over the last 30 years, and this review chronicles these changes and the reasons for them, and looks at how the current guidelines have been formulated.

NHS Choices defines 'major trauma' as multiple, serious injuries that could result in disability or death. In the scientific literature, major trauma is defined using the Injury Severity Score, which assigns values to injuries by body part. An Injury Severity Score >15 is defined as major trauma.

Worldwide, trauma is the leading cause of death and disability in people under 40 years of age. It is the fourth leading cause of death in western countries. The National Audit Office estimates that there are at least 20 000 major trauma cases in England every year. This results in 5400 deaths and leaving many others with serious permanent disability. Because the incidence of trauma is particularly high in younger patients, an average of 36 life years is lost for every trauma death (Chaira and Cimbanassi, 2003). For every trauma death, there are two survivors with serious or permanent disability (The Trauma Audit & Research Network, 2006). The National Audit Office estimates that the annual cost in immediate trauma treatment is between £300 and £400 million. The annual lost economic output as a result of major trauma is estimated at between £3.3 and £3.7 billion (National Audit Office, 2010).

The landscape in major trauma has evolved over the last 30 years in England and Wales. In 1988, a retrospective study in England and Wales identified that out of 1000 deaths from injury, up to 33% were preventable (Anderson et al, 1988). In the same year, the Royal College of Surgeons published the Report of the working party on the management of patients with major injury, which described 'serious deficiencies' in trauma care (Royal College of Surgeons of England, 1988). The document recommended the management of seriously injured patients in regional trauma centres and advised further research into major trauma, as well as a study into patient outcomes. As a result of this, the Department of Health pledged £2.8 million over 3 years for a pilot trauma centre at North Staffordshire (National Audit Office, 2010).

In 1992, the first major trauma outcome study looked at the care of 14 648 patients in 33 British hospitals. The study demonstrated a significantly higher mortality for blunt trauma when compared to the United States (Yates et al, 1992). Another report, from the British Orthopaedic Association (1997), outlined that major trauma patients in Britain were not receiving the same quality of care as patients in Germany, Switzerland and the United States. Later that year, the performance of the pilot trauma centre at North Staffordshire was evaluated and demonstrated a 'modest' reduction in mortality from trauma since its inception. The report recognized that the system had not yet developed into a comprehensive regionalized network. More significant improvements were thought to occur with wider integration along the entire pathway.

By 2002, progress had begun to plateau, with a study by the Trauma Audit & Research Network showing a lack of improvement in major trauma care since 1994 (Lecky et al, 2002). The National Confidential Enquiry into Patient Outcome and Death (2007) report entitled 'Trauma: who cares?' identified clinical and organizational deficiencies in major trauma, concluding that 60% of patients received care below that of good practice. In 2008, Lord Darzi's review of the NHS stated that there are 'compelling arguments for saving lives by creating specialised centres for major trauma'. As a result, strategic health authorities were asked to begin considering the formation of major trauma services (Department of Health, 2008). Two systematic reviews have demonstrated that mortality in a dedicated trauma centre is reduced by 10–20% (Mann et al, 1999; Celso et al, 2006). This paved the way for the current trauma network that exists in the UK today, which consists of 27 dedicated adults and children's major trauma centres. By this time, streamlining a radiology service in the context of trauma was becoming increasingly well recognized.

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In 2010, the NHS Clinical Advisory Groups produced 'Regional Networks for Major Trauma'. This report made several recommendations that apply to the radiology department:

- Emergency radiology facilities (such as computed tomography scanners) should be located within the emergency department
- Whole body computed tomography is the diagnostic test of choice (when patients are stable enough to be transferred for computed tomography)
- Magnetic resonance imaging should be available 24 hours a day at major trauma centres
- There should be agreed timelines and competencies in place for trauma reporting and documentation
- Teleradiology facilities should be available between all major trauma units within the network
- Interventional radiology should be available 24 hours a day, 7 days a week in a major trauma centre (NHS Clinical Advisory Groups Report, 2010).

The Royal College of Radiologists (2015) produced a further guideline that aimed to complement the 2010 NHS Regional Networks for Major Trauma document. This was entitled 'Standards of practice and guidance for trauma radiology in severely injured patients'. It details 18 standards that radiology departments in major trauma centres should be adhering to. Standards 11–13 are of particular interest for radiologists on-call in a major trauma centre:

- Standard 11 – The primary survey report should be issued immediately to the trauma team leader. It should be signed and designated and a copy should be retained in the computed tomography department
- Standard 12 – On call consultant radiologists should provide the final report on the SIP (seriously injured person) within 1 hour of multidetector computed tomography image acquisition
- Standard 13 – On-call consultant radiologists must have teleradiology facilities at home that allow accurate reports to be issued within 1 hour of multidetector computed tomography image acquisition.

The Royal College of Radiologists document also provides an example primary survey report for a major trauma computed tomography scan. The aim of this is to quickly identify urgent or potentially reversible pathologies, and to communicate them back to the trauma team leader. This 'checklist' type report is split into an ABCD structure.

- Airway. Is the endotracheal tube placement satisfactory? Is there airway obstruction?
- Breathing. Is there a pneumothorax, contusion or laceration? Is the chest drain placement satisfactory?
- Circulation. Is there evidence of thoracic, abdominal, pelvic or soft tissue bleeding?
- Disability. Is there intracranial bleeding or oedema, or major spinal injury?

The secondary report should go into more detail to look for more subtle pathologies, and as per standard 12, should be issued within 1 hour by the consultant radiologist. Any important findings not mentioned in the initial report should be communicated immediately with the trauma leader (The Royal College of Radiologists, 2015).

Imaging modalities

While the majority of trauma imaging is performed by multi-detector computed tomography, it is important to mention some of the other modalities available within a modern major trauma centre. In some scenarios, such as pregnant or paediatric patients, alternatives may be discussed between the consultant radiologist and trauma team leader.

Focussed assessment with sonography in trauma (FAST)

Focussed assessment with sonography in trauma (FAST) is a recent development in trauma. It has been used to rapidly identify free fluid suggesting injury to the peritoneal, pericardial and pleural spaces. The advantages include speed of examination, no ionizing radiation and being able to perform it in the emergency department without moving the patient (American Institute of Ultrasound in Medicine, 2014). There may be a role in triage of multiple, simultaneous seriously injured patients, but the Royal College of Radiologists states that FAST ultrasound does not convey any extra information compared to multidetector computed tomography, and it should not delay time to computed tomography. FAST is a poor discriminator for the need for laparotomy in trauma, with studies describing a 50–63% negative predictive value. FAST is very operator dependent and needs to be performed regularly to maintain the skill.

Magnetic resonance imaging

Magnetic resonance imaging is an important modality to consider when ligamentous, disc, spinal cord and occult osseous injuries are suspected (Saifuddin, 2001). While the workhorse of trauma imaging tends to be computed tomography, there are a few situations where magnetic resonance imaging is an appropriate adjunct. Alternatively, magnetic resonance imaging can be used to demonstrate pathology that could explain clinical symptoms that are not explained by a prior computed tomography.

Magnetic resonance imaging in the context of trauma is primarily used when a spinal cord pathology is suspected. Possible causes could include intramedullary haemorrhage, cord contusion, extrinsic compression from a fracture fragment, traumatic disc herniation or cord transection (Van Goethem et al, 2003).

Diffuse axonal injury and associated microhaemorrhages are sometimes difficult to appreciate on computed tomography, and several studies have demonstrated that

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magnetic resonance imaging is more sensitive in detecting this pathology (Gentry et al, 1988; Lee et al, 2008). Magnetic resonance imaging is also helpful in predicting neurological recovery (Kulkarni et al, 1987).

Computed tomography

Computed tomography evaluation in blunt trauma allows for rapid and accurate assessment of the brain, spine, chest, abdominal organs and pelvis (*Figures 1* and *2*). Rapid identification of injuries sustained during blunt trauma can improve patient outcomes and guide medical and/or surgical interventions. The development of multidetector computed tomography and improved processing power of hardware has allowed for improved multi-planar reformatting, and increased accuracy in detecting subtle pathology on computed tomography.

There is no universal guideline when it comes to a protocol for computed tomography in patients with polytrauma. Perhaps the most widely used is as follows:

- Standard unenhanced brain
- Dual bolus neck (from circle of Willis down), chest, abdomen then pelvis.

The dual bolus protocol is sometimes referred to as the Camp Bastion protocol. In Afghanistan, the military base's radiologists developed a procedure that allowed for biphasic injection: 65 ml at 2 ml/s, then 95 ml at 3.5 ml/s. The scan begins at 70 seconds while the contrast is still being delivered. This dual bolus technique allows simultaneous assessment of the vasculature in the arterial phase, and the abdominal viscera in the portal venous phase. Both of these are acquired on a single pass, thus minimizing radiation dose and reducing the amount of time the potentially unstable patient is in the scanner. Fast acquisition times of modern computed tomography scanners allow for the entire body to be scanned in a single pass (Graham, 2012).

The position of the arms during trauma computed tomography can affect the image quality as a result of a streak artefact. They can be positioned down for the head and neck and then up for the body. On balance, for patient comfort and rapidity of scanning, the authors recommend that an arms down approach throughout the whole body computed tomography produces images which are of sufficient quality to make a diagnosis with the streak artefact causing no significant diagnostic uncertainty for the experienced reporter. Alternatively, placing the flexed arms on a pillow positioned ventral to the chest gives similar results (Bayer et al, 2011; Karlo et al, 2011).

> **"The position of the arms during trauma computed tomography can affect the image quality as a result of a streak artefact."**

If there is suspicion of a pelvic or bladder injury, a delayed scan can be performed. The purpose of this is to demonstrate contrast extravasation from the bladder, which is in keeping with a traumatic bladder rupture. If a delayed

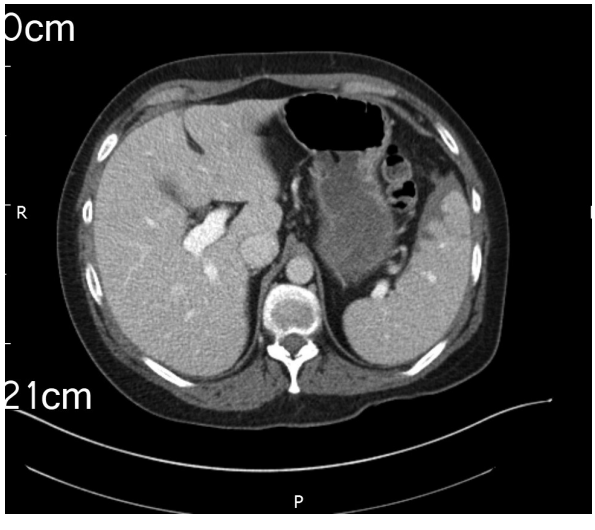

Figure 1. An example of a splenic laceration.

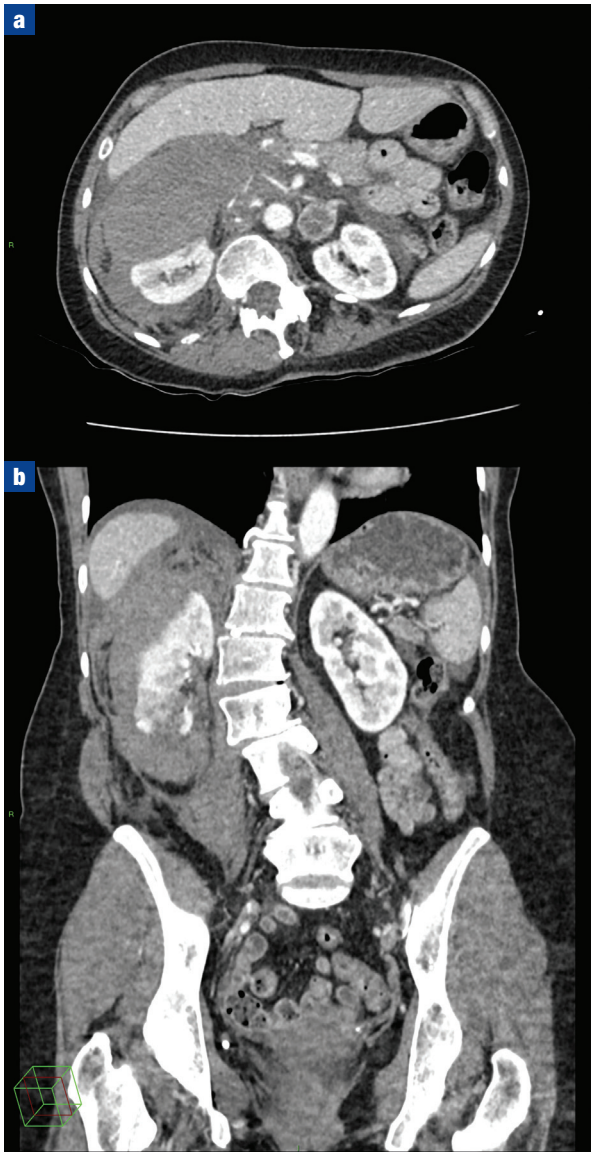

Figure 2. **a.** Axial and **(b)** coronal computed tomography images demonstrating a 'shattered' kidney with surrounding haematoma.

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KEY POINTS

- Worldwide, trauma is the leading cause of death and disability in young people.
- The landscape in major trauma has evolved over the last 30 years as a result of several government and independent reports.
- Current radiology guidelines reflect the importance of quickly recognizing serious, reversible conditions that often arise in trauma.
- The formation of specialized regional trauma networks in the UK reflect a new focus on the importance of robust trauma protocols.
- As advances in technology are implemented into the radiology department, the recognition of more subtle, important pathologies is likely to improve, and therefore, so should patient outcomes.

computed tomography scan is not feasible (perhaps as a result of added urgent pathologies), an alternative is to perform computed tomography cystography. This involves retrograde bladder filling with contrast via a urethral catheter, and then performing the 'delayed' computed tomography. A minimum of 200–300 ml of contrast is necessary to safely exclude rupture. Studies have shown computed tomography cystography as a highly accurate adjunct to trauma computed tomography in the right setting (Vaccaro and Brady, 2000).

Conclusions

Trauma continues to place a heavy burden on NHS resources and result in lost economic output. Patient outcomes in trauma have improved over the last 30 years, and this can be attributed to regional trauma network formations, as well as the optimization of radiological procedures. While the design of the trauma network model has been a central process, as the network expands it is important to consider each region individually so that the services meet local needs.

With regards to radiology, the workhorse for trauma in the immediate future lies with computed tomography. As computed tomography technology advances, the main role of trauma imaging remains quickly identifying critical, potentially reversible pathology. Future developments in computed tomography are likely to improve scan time and resolution, with reduced dose to patient. Software advances with multi-planar reformatting are also likely to improve recognition of more subtle pathologies. **BJHM**

The authors would like to thank Dr Amit Gaikwad, Consultant Radiologist, Yeovil Hospital, for providing Figure 2.
Conflict of interest: none.

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