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The Role of Interventional Radiology in Trauma Management

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Trauma represents a major burden to hospitals and healthcare systems, affecting 135 million people worldwide every year, with 5.8 million of these dying as a result (World Health Organization 2008). Within Europe, these injuries are mostly caused by road traffic accidents, as well as falls from heights and violent altercations (see Table 1). Worryingly, figures from the UK show that trauma is one of the few disease categories in which mortality is increasing (Department of Health 2008; Department of Transport 2008).

While severe injuries often require complex reconstruction and rehabilitation, the most pressing concern of any trauma team is stopping active haemorrhage, which is the most common cause of death in polytrauma patients. Blood loss triggers a downward spiral of decreasing blood pressure, hypothermia and acidosis, and early resolution of this lethal triad is vital.

The Importance of Imaging

Modern trauma management relies heavily on imaging, particularly CT scans. Increasingly, hospitals are locating CT scanners adjacent to or within emergency departments, to enable swift imaging with minimal delay, countering the ‘doughnut of death’ phenomenon of the 1980s. Most major centres now forego plain X-ray imaging in favour of diagnostic CT, as this provides much higher sensitivity, and can clearly demonstrate any active extravasation or bleeding. Evidence suggests that timely CT use increases the probability of survival for polytraumatised patients (Huber- Wagner et al. 2009).

Interventional Radiology

Interventional radiology (IR) is uniquely placed to assist in this crucial stage of trauma management. Not only can interventional radiologists easily interpret the CT scans and thus optimise the management of patients, but the IR techniques of embolisation and stent-grafting are extremely effective at stemming active haemorrhage.

Embolisation utilises image guidance to steer catheters to the site of bleeding, where occlusive agents such as gelfoam or coils can be selectively placed to stem the flow of blood. In addition to avoiding the iatrogenic trauma of surgical repair, embolisation is also suitable for surgically precluded injuries, such as blush-bleeding of the liver or kidney, and for locating and treating intimal vessel tears. Stabilising bleeding is the priority, even if surgical intervention is also needed at a later stage for bowel or parenchymal repair or resection.

Not only can embolisation help stem bleeding in important organs such as the liver, kidney, spleen and pancreas, it is also useful for treating retroperitoneal and pelvic haemorrhage, both of which are difficult to access surgically. External compression banding is the treatment of choice for venous pelvic haemorrhage, reducing organ pressure and aligning bones, but early angiography and embolisation are essential for treating arterial bleeding (Cook et al. 2002). Multi-slice CT with IV contrast is particularly useful in identifying the presence of pelvic haematoma, as well as the presence and the site of arterial bleeding.

Stent-Grafts and Stents

Penetrating or blunt trauma can cause the aorta and peripheral vessels to be punctured, dissected or otherwise, and scaffold materials such as bare stents and stent-grafts can be deployed via catheter delivery to stop life-threatening haemorrhage, re-establish tissue perfusion and prevent delayed haemorrhage.

Thoracic aortic injury is the second most common cause of death in patients with blunt injury: it is estimated that 85% of these patients die before reaching the hospital (Garcia-Toca et al. 2010; Aladham et al. 2010). Using image guidance and catheters, a stent-graft can be delivered to the site of injury, providing support for the damaged vessel, as well as stopping the bleeding while preserving normal blood flow.

In recent years, this procedure – TEVAR (thoracic endovascular aortic repair) – has become widely used. This is due to the sound body of evidence that shows that the procedure has a lower mortality and morbidity rate than traditional surgical therapies in the thoracic aorta.

0-4 years	5-14 years	15-29 years	30-44 years	45-69 years
#8: Road traffic injuries (1,740)	#1: Road traffic injuries (4,180)	#1: Road traffic injuries (39,300)	#4: Road traffic injuries (33,200)	#16: Road traffic injuries (36,500)
#17: Violence (690)	#9: Violence (640)	#3: Violence (14,900)	#8: Violence (22,600)	
#19: Falls (660)	#13: Falls (530)	#13: Falls (3,590)	#15: Falls (7,900)	

Table 1. Causes of death by age group and frequency. European Region, 2004 (WHO Statistics)

In one meta-analysis of ruptured descending aortic repair (Jonker et al. 2010), including 224 patients treated between 1995 and 2011 (mean age 70 years), a significantly lower 30-day mortality rate was revealed in the TEVAR group. Moreover, myocardial infarctions and paraplegia occurred more often after open repair.

Another meta-analysis comparing open vs. endovascular repair in 589 patients (mean age 38.8 years) suffering from traumatic rupture of descending thoracic aorta also revealed a significantly lower procedure-related and 30-day mortality rate after TEVAR (Xenos et al. 2008). In a sub-analysis, the risk of procedure-related spinal ischaemia was also significantly lower in the endovascular group.

In many institutes, such as the Klinikum Passau in Germany and elsewhere, TEVAR is the treatment of choice for thoracic aortic injury, and open repair in thoracic aortic diseases is now reserved predominantly for ascending and aortic arch pathologies.

A Boon to Any Hospital

When included as part of a trauma team's repertoire, these techniques can vastly enhance the patient's outcomes. The goal of trauma management is damage limitation – helping minimise and resolve the injury caused to the patient – and favouring minimally invasive techniques over surgical repairs helps avoid further iatrogenic trauma.

Surgery is still required for major tissue damage, such as diaphragmatic tears and bowel injuries, but appropriate imaging and interpretation allow for optimal referral, ensuring that patients are treated speedily and appropriately, and making best use of a hospital's resources.

Guidelines

While no binding regulations are currently in place to ensure the inclusion of IR in the trauma team, a glance at the websites of Level 1 Trauma Centres across Europe shows that interventional radiology is widely utilised. Reflecting the growing interest in improving trauma outcomes across Europe, many countries, such as the Netherlands, Germany, France and the UK, are establishing networks of Level 1 Trauma Centres. The UK National Institute for Health and Care Excellence (NICE) Guidelines on major trauma care are currently being drawn up, with an estimated publication date of June 2015.

Additionally, professional societies such as the Cardiovascular and Interventional Radiological Society of

Europe (CIRSE) have published best practice guidelines (Chakraverty et al. 2012). One of the authors of CIRSE's Quality Improvement Guidelines for Endovascular Treatment of Traumatic Hemorrhage, Prof. Otto van Delden outlines the role such documents play:

"This important document highlights several key facts about IR's involvement in trauma care. It is vital to offer a 24/7 service, to be called early in the course of the case, to have all the logistics in place, and to have on-call rotas for everything.

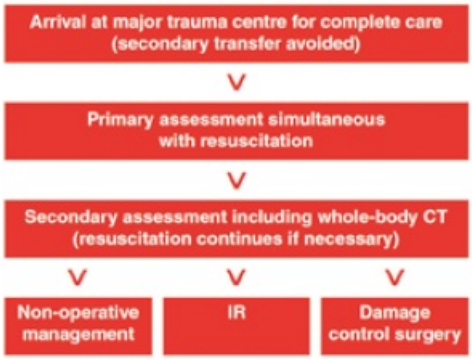

Figure 1.
Major trauma centre patient journey

Adapted from CIRSE Standards of Practice document Quality Improvement Guidelines for Endovascular Treatment of Traumatic Haemorrhage (Chakraverty et al. 2012)

"There is still a lot of work that needs to be done in implementing this, but the move towards Level 1 Trauma Centres is visible everywhere in Europe. Smaller hospitals are not equipped to handle severe trauma and care should be centralised. This Standards of Practice paper is a decisive step in the right direction."

Image 1. Amsterdam Trauma Workflow: Potentially harmful transfer of patients from trolley to table is avoided by using a single trauma trolley on which the patient stays from resuscitation onwards. All other equipment, including the CT scanner, is compatible with this trolley.

Optimising Logistics

Prof. van Delden is recognised as one of Europe's foremost trauma IRs, and enjoys an excellent working relationship with his colleagues. While acknowledging his hospital's reliance on IR techniques, he remains firm in his belief that a multi-disciplinary team is the only way to approach such complex cases: "We have a dedicated trauma team that consists of an anaesthesiologist, surgical residents, radiology residents, trauma surgeons, and radiologists – it's a fixed team. Trauma surgeons are very much the case managers: their skills in this field extend beyond performing surgery.

They are leading the case, supervising all the imaging and treatment types: the anaesthesiologist initiating ventilation of the patient, a resident or nurse inserting a chest tube, the radiologists interpreting the imaging studies; all of this is managed by the trauma surgeon."

His hospital, the Academic Medical Center of the University of Amsterdam, also has an excellent logistical set-up. Alongside 24/7 rotas and smooth teamwork, the hospital has invested in a dedicated CT scanner. This guarantees an efficient workflow and prevents the dangerous transfer of critically ill patients, as well as avoiding delays and inconvenience to non-emergency patients who have scans scheduled in the radiology department. Moreover, their innovative set-up utilises a sliding CT gantry that sits on rails. It serves two emergency rooms, with a radiation- shielding wall that can close behind it, and allows CT to be performed feet-first so IV-lines and monitors do not need to be re-positioned.

The Benefits of IR in Trauma Care

Trauma patients are often young, active patients, and being able to improve survival rates for patients who are otherwise in their prime has obvious social and economic benefits. Interventional radiology can actively contribute to reducing the rate of accident fatalities, and should be considered by any accident and emergency department which does not already benefit from this unique skill-set, and by any healthcare authority which wishes to improve its trauma outcomes.

Offering cutting-edge IR therapies positively contributes to the reputation and performance of any trauma centre. This helps not only the patients themselves, but also the hospital as a whole, preventing patients from entering that rapid downhill spiral of acidosis, hypoxia, and hypothermia, keeping them out of intensive care or reducing the length of their stay there.

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