

## **SECTION I**

# **General circumstances**

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# The development and organisation of trauma services

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### OVERVIEW

This chapter aims to:

- define major trauma
- highlight that major trauma is a common cause of death and disability worldwide
- discuss the evidence-based strategies that exist to improve outcomes following trauma
- identify each aspect of trauma care from prevention through to rehabilitation that must be developed to achieve optimal outcomes
- provide an overview of the development of major trauma systems in the UK and abroad.

The importance of injury prevention cannot be overstated. It is the most cost-effective way of dealing with trauma.

## Introduction

### Definitions

Depending on the context, the term, 'major trauma' has various meanings. Academically, it is defined by an injury severity score (ISS) of greater than 15 (see Chapter 33 – Evaluating the effectiveness of trauma care – Anatomical scoring system). However, the ISS is a retrospective calculation based on the anatomical nature of the injuries, so it cannot be used at the time of the patient's initial presentation to medical care. It should also be appreciated that 'moderate trauma' (i.e. ISS 9–15) can be associated with significant mortality and morbidity, especially at the extremes of age. Some complex isolated limb injuries may have a relatively low ISS yet result in significant morbidity and require specialist management.

As the focus of this book is on the clinical care of the injured patient, we follow UK NHS major trauma networks guidance (NHS Clinical Advisory Group on Trauma, 2010) and describe major trauma as a serious injury, or injuries, which may result in death or disability.

## The impact of major trauma

Major trauma represents a significant burden to global health. The World Health Organization (WHO) reports that, every day, 16,000 people die of injuries, with many thousands more suffering

significant morbidity and permanent disability (Mock et al., 2004). In the United States, trauma is the leading cause of death in those under 45 years of age (American Association for the Surgery of Trauma, 2019). A similar impact is seen in England where the National Audit Office data (2010) identified 5400 deaths annually due to injury and at least 20,000 cases of permanent disability. The immediate treatment costs to the NHS in England were assessed to be around £400 million, excluding any continuing rehabilitation or support. There is also an estimated additional loss to the economy of £3.7 billion due to the inability to work because of injury (National Audit Office, 2010).

Worldwide, there is significant discrepancy in the outcomes from major trauma when comparing high- and low-income settings. The mortality from moderate severity trauma ranges from 6% in high-income countries to 36% in low-income settings. The WHO (2004) concluded that, 'Much of the improvement inpatient outcome in higher-income countries has come from improvements in the organisation of trauma care services.' When considering how to establish and develop these services, it is essential to start at the right place. 'How should a severely injured patient be resuscitated?' is only one aspect of what is needed. Asking the broader question of 'How can the impact of major trauma be reduced?' is more inclusive but requires a macro view of the system. To do this, it is necessary to identify and address:

- How can serious injury be prevented?
- If trauma does occur, how can the severity be reduced at the time of injury?
- What trauma system should be in place to ensure optimal care is delivered in the right place and at the right time?
- How should the injured patient be managed both acutely and definitively?
- How can effective rehabilitation be used to ensure the optimal level of recovery is achieved?

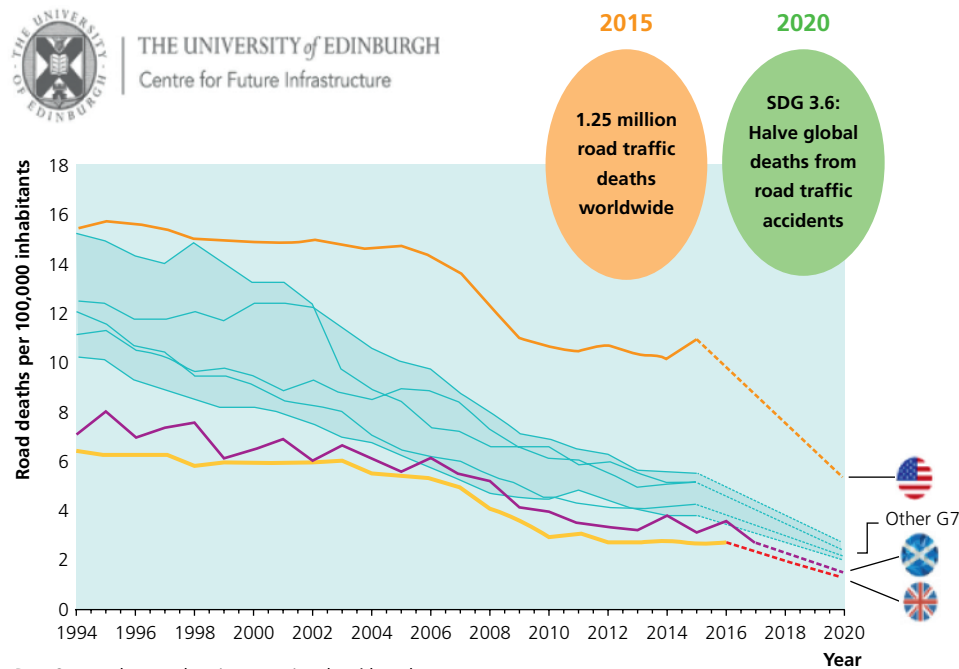
Each of these points is considered in this chapter.

## Injury prevention and reduction of severity

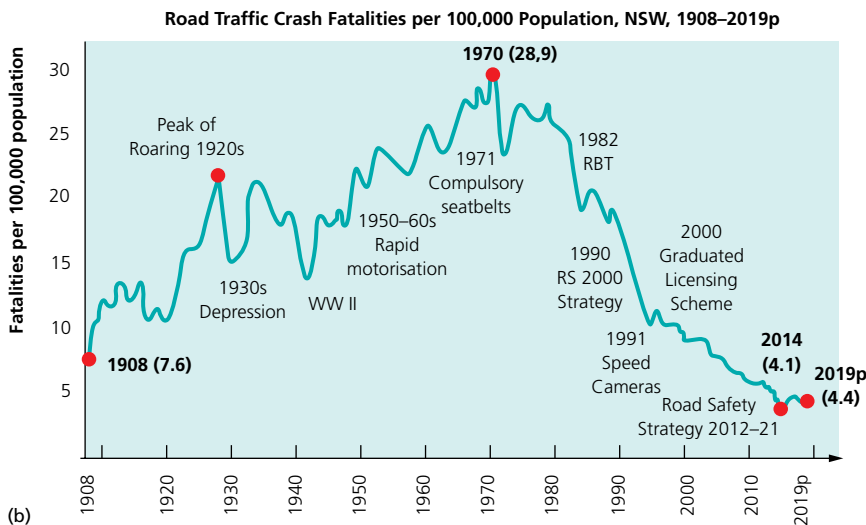
There are numerous initiatives that have reduced the incidence of trauma, incorporating many legislative procedures, particularly in high-income countries. Examples include a broad range of measures such as health and safety legislation in the workplace, mandatory vehicle safety standards, drink-driving laws, speed restriction measures, firearms licensing and targeted knife crime initiatives.

Strategies to minimise the severity of injury should a traumatic event occur can be best illustrated by the efforts of the

automotive industry. The US National Highway Traffic Safety Administration (2021) identified that, in 2009, there were nearly 15,000 lives saved in America simply by wearing a seat belt. The continuing development of vehicle safety features, from airbags to automatic assisted braking, also continues to reduce death and morbidity from injury. Similar effects are seen in the UK and other countries (Figure 1.1). This trend has led to more people surviving what would otherwise have been a fatal traumatic event. The challenge in these patients is to optimise their initial management and definitive care. Although often overlooked,



(a)



(b)

**Figure 1.1** (a) G8 road traffic deaths since 1994 and projection to the UN sustainable development goals. SDG = Sustainable Development Goal. Source: Edinburgh Futures Institute; Masterton (2018) Reproduced with permission from The University of Edinburgh. (b) Road traffic collision fatalities per 100,000 population, New South Wales, Australia. RBT = Random Breath Test. Source: Transport for NSW (2020).

experience shows that the latter must include a continuing process of rehabilitation to maximise their return to as near their pre-accident state as possible.

## The trauma system

### History

In 1966, the US National Research Council published *Accidental Death and Disability: The neglected disease of modern society* (National Academy of Sciences (US) and National Research Council, 1966). This seminal work concluded with key recommendations, which included the need for optimal care starting in the prehospital phase and the accreditation of hospitals based on their abilities to deliver different levels of care. About this time, a state-wide trauma system was launched in Illinois, using Cook County Hospital in Chicago as the major receiving centre. It had five key components (Box 1.1). Since that time, this framework has evolved and spread throughout the United States (Mullins, 1999), with many countries worldwide also adopting similar processes.

#### Box 1.1 Key components of the Illinois trauma system (Mullins, 1999)

- An appropriate ambulance service.
- Designation of hospitals as trauma centres.
- Specific training for health professionals.
- Improved communication within the system.
- A trauma registry.

In the late 1980s, there was a resurgent interest in trauma care following a Royal College of Surgeons of England report on the management of patients with major injuries (Saleh, 1989). Fledgling trauma care systems began to emerge, paralleled by the development of emergency medicine and pre-hospital care as recognised specialties in the UK. There has also been a huge increase in trauma training including courses, such as Advanced Trauma Life Support (ATLS), the Anaesthesia Trauma and Critical Care Course, the European Trauma Course, the Trauma Nursing Core Course, the Advanced Trauma Nursing Course and the Trauma Immediate Life Support Course.

In England, there had been several publications and recommendations highlighting the need for a more integrated system with some regions attempting to develop specific pathways for major trauma (Nicholl and Turner, 1997). However, concerns continued to be raised regarding trauma care. The publication of the NCEPOD report, *Trauma: Who Cares?* (NCEPOD, 2007), highlighted that 60% of patients studied received suboptimal care. Trauma care subsequently became the focus of a national strategy, with the first national clinical director for trauma being appointed in 2008. By 2012, following the mandatory development of regional major trauma networks, every area in England had established a system of major trauma centres (MTCs), trauma units and a directory of pathways to optimise trauma care (Figure 1.2). These pathways emphasised the need for timely and definitive care. To achieve this,

ambulance and helicopter services were empowered to take patients directly to MTCs when appropriate. To help further with rapid access to specialist care, it also mandated direct transfer of patients from trauma units to MTCs if required. The aim was to get the patient to the most appropriate facility as safely as possible in a timely fashion.

### The components

The separate parts of a trauma system are complex and wide-ranging (Box 1.2). To be inclusive, all the potential stakeholders need to be recognised and represented. In this way, the whole patient journey can be considered from pre-hospital providers through to rehabilitation. It is therefore essential that there is coordination and clinical leadership in both the establishment of a system and its continuing management. The latter, in particular, requires a process of active engagement with representatives from the whole system so that consistent, best practice is delivered, and areas for improvement are identified and actioned.

### National Institute for Health and Care Excellence guidance

The National Institute for Health and Care Excellence (NICE) has produced several key documents dealing with the management of injured patients in the trauma care system. *Major Trauma: Service delivery* (NG40) was published in 2016 and includes recommendations on pre-hospital triage, the destination of patients with major trauma and the organisation of trauma services (National Institute for Health and Care Excellence, 2016a). In addition, it provides guidance on documentation, audit and provision of information and support for patients, their relatives and carers.

In the same year, NICE produced the supporting guideline, *Major Trauma: Assessment and initial management* (NICE, 2016b). This document's aims are to reduce deaths and disabilities in people with serious injuries by improving the quality of their immediate care. In so doing, it covers the rapid identification and early management of major trauma (excluding burns) in pre-hospital and hospital settings, including ambulance services, emergency departments, major trauma centres and trauma units.

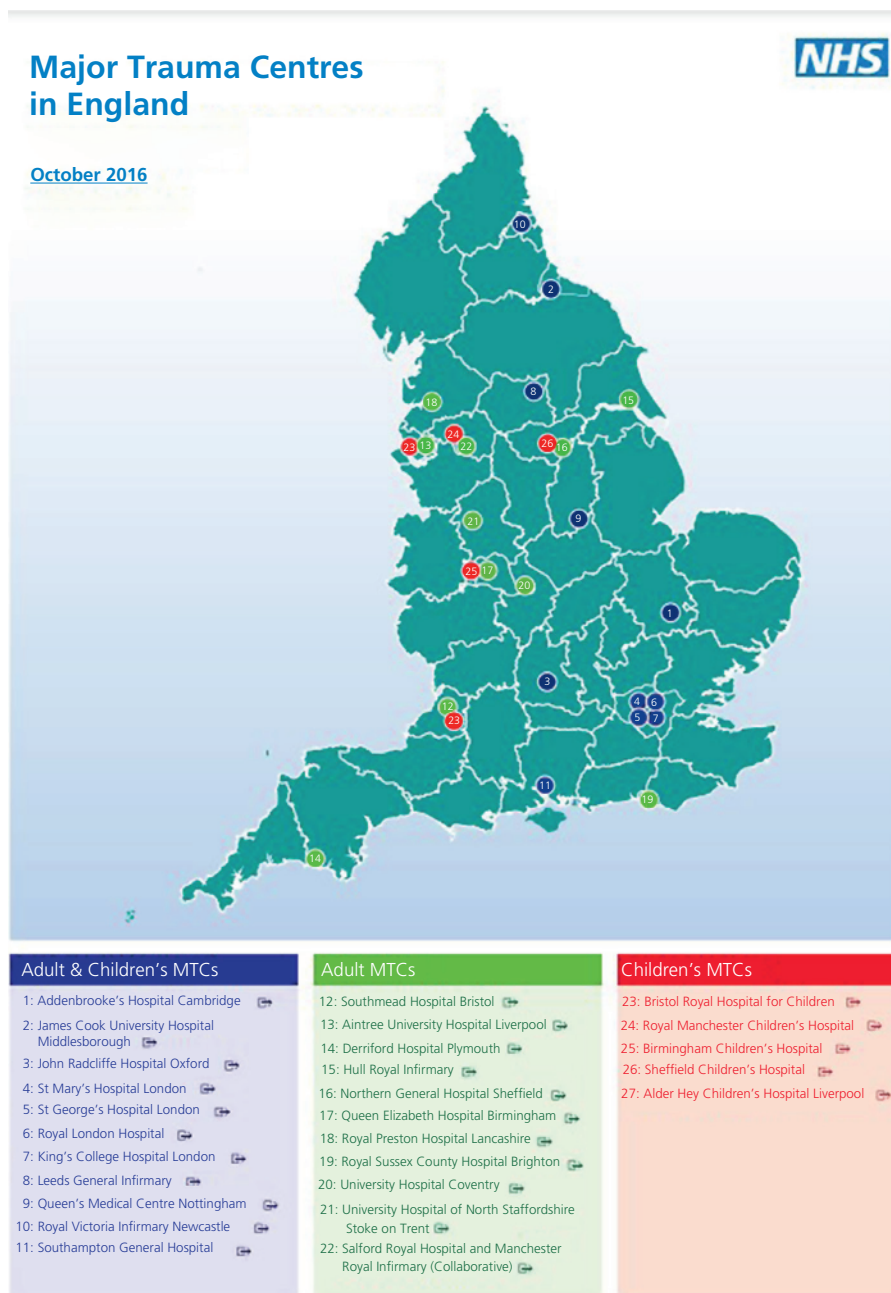
These two documents are referred to on numerous occasions throughout this book, as they provide the basis for the management of several trauma conditions encountered in the prehospital and hospital settings.

## The major trauma care pathway

The major trauma care pathway can be divided into four stages: pre-hospital care, reception, definitive care and rehabilitation (Figure 1.3). Each of the links in this pathway, from roadside to rehabilitation, and the flow between them, must be as strong and efficient as possible.

### Community training

A holistic approach, where every aspect of trauma management is optimised and all stakeholders are involved is what makes an effective trauma system. A false assumption is that this process



**Figure 1.2** Major trauma centres in England. Source: NHS England.

commences with the arrival of the first medical personnel. In fact, the actions of 'zero responders' (i.e. those people who happen to be there at the time of the incident) can be critical. In addition to calling the emergency services, basic actions by passing members of the public, including haemorrhage control and simple airway management, can be lifesaving. Consideration should therefore be given to further public initiatives to improve the chances of the severely injured patient receiving good-quality immediate first aid. This can be enhanced by the inclusion of first aid training in the workplace or within the school curriculum (Frederick et al., 2000).

### Pre-hospital

The aim of the major trauma care pathway is to ensure that the patient receives the appropriate treatment at the correct time with resources that are accessible. Typically, this will mean identifying cases requiring the specialist interventions available only at an MTC and transferring them there with appropriate pre-hospital care. Inevitably, there will be some patients who will be too unwell to survive the potentially extended transfer directly to an MTC. To cover this possibility, the network must provide rapid transfer to the closest trauma unit for urgent stabilisation and then secondary transfer to the MTC if appropriate. For

example, a patient with a low level of consciousness with a difficult airway may require anaesthesia and intubation at a trauma unit before onward transfer to an MTC for neurosurgical intervention.

Another option is to access, where possible, the advanced pre-hospital care services which provide specialist physician and paramedic teams to a large geographical area by helicopter or rapid response vehicles (Figure 1.4). This provision of advanced trauma

#### Box 1.2 Components of an inclusive trauma system (NHS Clinical Advisory Group on Trauma, 2010)

##### Trauma network

This is the name given to the collaboration between the providers commissioned to deliver trauma care services in a geographical area. In particular, it includes the pre-hospital services, other hospitals receiving acute trauma admissions (i.e. major trauma centres and trauma units) and the rehabilitation services. The trauma network must also have appropriate links to the social care and the voluntary/community sector. While individual units retain responsibility for their clinical governance, members of the trauma network need to collaborate in a quality improvement programme with each hospital in the network contributing to continuing trauma audit (see Chapter 33 – Evaluating the effectiveness of trauma care – Introduction).

##### Major trauma centre

A major trauma centre is a multispecialty hospital on a single site, optimised for the provision of trauma care. It is the focus of the trauma network and manages all types of injuries, providing a consultant-level delivered service. In doing so:

- It provides all the major specialties relevant to the care of major trauma (i.e. emergency medicine, general surgery, vascular, orthopaedic, plastic, spinal, maxillofacial, cardiothoracic and neurological surgery and interventional radiology) together with appropriate supporting services, such as critical care.
- It delivers definitive care of injured patients. In particular, it has an effective trauma quality improvement programme. It also provides a managed transition to rehabilitation and the community.
- It takes responsibility for the care of all patients with major trauma in the area covered by the network. This includes support for the quality improvement programmes of other hospitals in the same network.

- The Royal College of Surgeons of England cites research advising that such centres should admit a minimum of 250 critically injured patients per year.

##### Trauma unit

A trauma unit is a hospital in a trauma network that provides care for most injured patients and:

- It is optimised for the definitive care of injured patients. In particular, it has an effective trauma quality improvement programme. It also provides a managed transition to rehabilitation and the community.
- It has systems in place to rapidly move the most severely injured to hospitals that can manage their injuries.
- It may provide some specialist services for patients who do not have multiple injuries (e.g. closed tibial fractures). In these cases, the trauma unit takes responsibility for making these services available to all patients in the network who need them. Other trauma units may have only limited facilities, being able to stabilise and transfer serious cases but only admitting and managing less severe injuries.

##### Local emergency hospital (not designated as a trauma unit)

The local emergency hospital is also part of the trauma network, as it may have a role in the rehabilitation of trauma patients and the care of those with minor injuries. However, it does not routinely receive acute trauma patients, except minor injuries that may be seen in a minor injury unit. It therefore needs to have processes in place to ensure that should a major trauma case present, they are appropriately triaged and transferred to a major trauma centre or trauma unit.



Figure 1.3 The major trauma care pathway.



**Figure 1.4** A purpose-built helipad on the roof of a major trauma centre. Source: Courtesy of D. Bramley.

care at the site of the incident is supported in England by NICE (2016b), which recommends that rapid sequence intubation should be delivered at the scene when required. Since the publication of these guidelines, there have been further developments in the delivery of on-scene advanced care, including blood transfusion and resuscitative surgical interventions. As there is evidence that such services are beneficial in major trauma outcomes (Smith et al., 2019) it is essential that these are fully integrated into the trauma network.

### Bypass protocol

The development of major trauma network guidelines, informed by NICE (2016a,b) are important in helping teams to make best-practice decisions regarding the standards of triage and treatment. This facilitates consistency within a network, for example which patients can be taken directly to the MTC (Figure 1.5). It is also used by pre-hospital personnel to ensure that the patient gets to the most appropriate facility as quickly and efficiently as possible.

### Reception and resuscitation

The trauma team leader in the receiving hospital is pre-alerted by the pre-hospital care team (see Chapter 2 – Pre-hospital trauma care – Emergency department pre-arrival alert). This enables the trauma team to be assembled and prepared for the patient's arrival. The team's priorities are:

- Identifying and treating immediately life-threatening conditions: this initial phase of the resuscitation will typically include computed tomography and, in some cases, emergency surgery or interventional radiology.

In the UK, there is a defined subspecialty of pre-hospital emergency medicine, which ensures that doctors working in this environment are trained to a consistent and appropriate standard (the Intercollegiate Board for Training in Pre-Hospital Emergency Medicine; [www.ibtphem.org.uk](http://www.ibtphem.org.uk)).

- Once stabilised, the patient needs to be examined fully so that all other injuries and medical conditions are found. With this information, a definitive care plan can be devised.

To achieve these objectives, the team needs to carry out several tasks simultaneously in a coordinated fashion under the direction of the trauma team leader (see Chapter 3 - Initial Assessment and resuscitation of the trauma patient – Team organisation).

### Definitive care

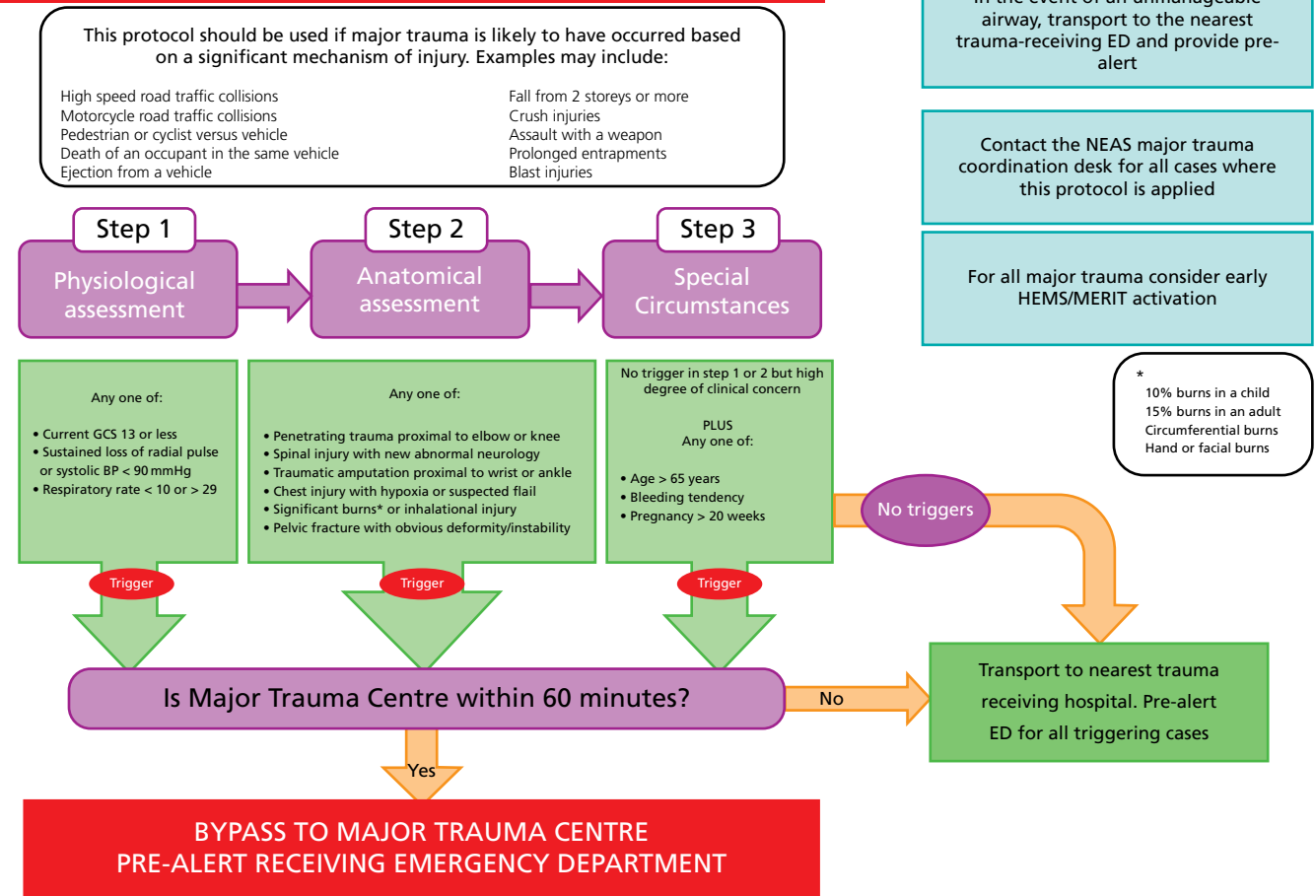
The continuing care of the trauma patient after the initial resuscitation phase involves a multidisciplinary consultant-led team approach from several specialties. There have been significant improvements in the immediate response to the patient with traumatic injuries. However, it is essential that the resources required to provide the best chance of recovery and rehabilitation are available and provided for all who need them. This includes continuing physical and psychological support and interventions following hospital discharge.

Where resources are provided is dependent on the capabilities of the hospital concerned. The aim of the network bypass protocol is to get the right patient to the right place (MTC or trauma unit). However, even with effective bypass protocols in place, trauma units must be prepared to receive major trauma cases (Box 1.3).

The MTC trauma team leader needs to be notified of such cases as soon as is practical so that, if necessary, they can facilitate rapid transfer to the MTC emergency department. The need for transfer is solely based on clinical requirement: it must not depend on being able to speak to the particular specialist or the availability of a suitable inpatient bed at the MTC. In some areas, specialist paediatric transfer and retrieval services are available. However, this must not cause delays in the transfer of the patient with time-critical injuries. Instead, transfer guidelines should be developed, in collaboration with such services, to ensure safe and efficient movement of the child with major trauma.

It is equally important that trauma units prioritise the transfer back of patients who have been managed at the MTC but who now have needs,

## Major Trauma Bypass Protocol



**Figure 1.5** An example of an ambulance service major trauma bypass pathway. Source: The Northern Trauma Network for use by North East Ambulance Service (NEAS) and Great North Air Ambulance Service.

### Box 1.3 Situations when a major trauma case may present at a trauma unit

- Deliberate transfers due to patient instability precluding direct transfer to a major trauma centre.
- Occult major trauma that on prehospital triage appeared to be insignificant.
- Patients, especially children, who are brought directly to the closest hospital by family or friends.

particularly rehabilitation, which can be met in their local trauma unit. This is necessary to avoid bed blocking at the MTC and requires dedicated trauma coordinators to facilitate the process (see Chapter 4 – The role of the Trauma nurse – Trauma nurse co-ordinators).

### Secondary transfer

Trauma networks are designed such that secondary transfer between hospitals is minimised and, when it does occur, it is at the appropriate time. Furthermore, as these networks are self-sufficient, only occasionally will a patient need to move from one region to another

for their optimal care. An example of this would be a patient involved in a serious incident in one part of the country might require MTC care there but could then return to their own region for continuing management. Communication in these cases is crucial, and trauma networks should ensure that processes are in place for such events.

There are also some relatively uncommon injuries with specific management requirements that prevent delivery in every area, such as burns care or spinal injury rehabilitation. In such cases, it may be appropriate to have national, or multiregional, injury-specific networks (e.g. a burns care network) linked with regional trauma networks to ensure fluent and consistent care.

### Rehabilitation

Continuing rehabilitation and support for major trauma patients is crucial for optimal outcomes. Despite very significant changes to the emergency care of patients with injuries, the need to develop and improve rehabilitation services cannot be underestimated (see Chapter 21 – Rehabilitation of the trauma patient – Introduction). This may take the form of general and specialist services in both hospitals and community. As such, there is a requirement for a specific rehabilitation ‘prescription’ for each patient that allows

seamless continuing care whether the patient moves from one ward to another, from a particular hospital to another, or from hospital care to discharge and community care.

### Major incidents

When an incident gives rise to multiple casualties, the existing relationships between the various trauma-receiving hospitals in the network are invaluable. They provide familiar communication channels between the prehospital teams and the hospitals. This enables the most efficient use of the available patient capacity, both in the initial phase of the incident and on the subsequent days after (for further details, see Chapters 29 – Major Incidents pt.1: The Emergency Services response at the scene and 30 – Major Incidents pt.2: The hospital response).

### The effectiveness of change in the trauma care system

Having seen a wholesale reorganisation of the trauma system in England, an obvious question is, has it been of benefit? A study of patient data between 2008 and 2017 demonstrated a 19% increase in probability of survival for patients with an injury severity score of nine or more and concluded that, 'A whole system national change was associated with significant improvements in both the care process and outcomes of patients after severe injury' (Moran et al., 2018).

It is therefore vitally important that MTCs and trauma units undertake regular trauma audit meetings and debriefings at a hospital and network level, and submit data to national trauma databases (see Chapter 33 – Evaluating the effectiveness of trauma care – Trauma Audit and Research Network (TARN)). This can inform change and allow evaluation of an individual case and performance against a cohort of cases or similar units. It is also an essential part of the peer review system for MTCs and trauma units.

### Other UK trauma system developments

The evolution of major trauma networks is dependent on several different factors, including a multidisciplinary clinical approach, resource availability, geography and managerial/political support. What has been described above is very much the development of the major trauma system and networks in England. There has been similar planning undertaken in the UK devolved nations within slightly different timescales.

#### Scotland

The Scottish Cabinet Secretary for Health and Sport set out a clear commitment in May 2016, to implement a bespoke Scottish Trauma Network consisting of an inclusive network of hospitals, four MTCs and an integrated network infrastructure. This commitment was subsequently included as a key outcome in the Programme for Government in 2016. The four MTCs are in Aberdeen, Dundee, Edinburgh and Glasgow surrounded by four regions, North, East, Southeast and West of Scotland. The network was established in 2017, and the first MTCs opened in 2018 using similar prehospital triage and bypass protocols to other parts of the UK (see Chapter 20 – Transfer of the trauma patient, Figure 20.3).

#### Northern Ireland

The Northern Ireland Major Trauma Network was established in December 2016 following a commitment by health ministers to establish an integrated trauma service alongside a helicopter emergency medical service. The latter was launched in July 2017. The network comprises commissioners from the Health and Social Care Board and Public Health Agency, as well as clinical and service leaders from health and social care trusts including the Northern Ireland Ambulance Service. It provides the infrastructure, in line with international best practice. This allows healthcare professionals, commissioners and other stakeholders to collaborate across the health and social care system to plan, coordinate and manage the treatment of people suffering from major trauma. It also includes injury prevention, pre-hospital care, acute specialty services at the MTC (Royal Victoria Hospital, Belfast), local emergency departments and rehabilitation services.

#### Wales

In Wales, the northern hospitals were part of the Northwest, Midlands and North Wales Trauma Network, as this developed with the English timetable for implementation as outlined above. In 2018, plans were announced by the Welsh government to establish a major trauma network for South Wales, West Wales and South Powys. Planning went on throughout 2019 with implementation of the service in September 2020.

### International trauma systems

#### Europe

Germany, Austria and a number of other mainland European countries have upgraded their trauma care in the last decade based on strategic development in the pre-hospital system, in hospital treatment, networks and training.

#### Pre-hospital system

In Germany and Austria, the pre-hospital assessment and treatment are based on physicians on scene. In most areas, a rapid response vehicle, staffed by a pre-hospital emergency physician and a highly trained emergency medical technician, will be the first emergency medical response on scene. In addition, most European countries have a physician-staffed helicopter ambulance system. These clinicians are typically hospital-based specialists with additional training. Many come from anaesthesia and intensive care, but there are also trauma surgeons, specialist internal medicine doctors and general practitioners.

Most ambulance systems are equipped with advanced diagnostic and therapeutic equipment (e.g. ultrasound, blood gas analysis, basic blood sampling and blood for transfusion) in addition to the generic equipment required for safe, effective pre-hospital trauma management. There are professional dispatching and guidance units to ensure that the pre-hospital time is used effectively. These include telemedicine support for the teams on scene, which helps to organise the best designated hospital for the patient. This resource is continuing to develop such that it now provides diagnostic support as well as an online preview of the patient's situation and findings. It therefore helps the receiving hospital to prepare the right equipment even before arrival.

Depending on the severity of the patient's injuries, transport to the appropriate hospital can be carried out with or without the pre-hospital physician. Consequently, this system allows specialised clinicians to be focused on those patients with the greatest need of their advanced skills.

### In hospital treatment

The members of the hospital trauma team are principally drawn from anaesthesia, the independent subspecialty of trauma surgery and from radiology. The team leader role is not necessarily undertaken by any particular specialty but by the person who has the experience and training to undertake that role. This may vary between centres according to the local protocol. The trauma surgeons are trained to undertake focused assessment sonography for trauma and emergency surgery for abdominal, chest and limb injuries and more. Typically, they can also call for additional help from other surgical specialties for more complex injuries. In many centres, inpatient care and rehabilitation also come under the umbrella of the trauma surgery department (Sturm et al., 2013).

### Network and training

Most regions are setting up or running trauma networks. As secondary transfers reduce survival rates, efficient primary triage guidance is playing a major role in the treatment of the severely injured patient. Within the network, a well-structured and organised system of hospitals, together with the triage system, allows for the patient to be sent to the most appropriate facility.

The network and individual hospitals are subject to ongoing audit. This takes into account quantitative (e.g. how many patients and in what time?) and qualitative (e.g. what injuries based on what experience can be treated?) data. The assessment and maintenance of quality continue to be a significant motivator in striving for improvement. Training programmes are part of the strategy to ensure that there is standardised and up-to-date quality in the members and the function of the trauma teams. Although local and national initiatives are used, the training also includes internationally recognised programmes such as the European Training and ATLS courses.

### Australia

The challenges of the Australian trauma system aid innovation and development.

Australian trauma management presents unique challenges. There are 25 million people populated across a large continent, with 80% in coastal zones and 38% outside major cities. The country's trauma systems are state based, with a hub-and-spoke model. This is in response to the need to ensure patient stabilisation prior to onward transfer to definitive care. Rural trauma is overrepresented in Australia. This, coupled with the tyranny of distance, has led to the development of a mature retrieval system across road, rotary and fixed-wing platforms to underpin the hub-and-spoke model of trauma care.

Major trauma services are designated by each state government, with a recent focus on formal analysis and verification processes. The latter was developed by the Royal Australian College of Surgeons (2021) but it is supported by the Colleges of Anaesthetics,

Emergency Medicine and Intensive Care Medicine, as well as the Australian Trauma Society. Hospitals are designated Level I–IV, with each state having variable numbers of designated major trauma services. These services are not necessarily reflective of the population, with some also functioning as the referral centres for burns and spinal cord injury. There are also separately designated paediatric trauma services in large cities.

Blunt force trauma makes up 94% of severe trauma, with transport-related mechanism causing 45% of injuries, followed by falls (36%). As in other jurisdictions, elderly low falls make up an increasing burden of severe trauma. This 'silver tsunami' accounts for 20.4% of all severe injuries, with 15% mortality and 87% of deaths over 65 years. 70% of the severely injured are transferred from scene direct to definitive care (major trauma service) by road ambulance (73.5%), helicopter (18.4%) and private vehicle (5.8%). It follows that the 'golden hour' is a pre-hospital event in Australia with 1 hour 26 minutes being the median time from scene to definitive care, followed by an emergency department median time of 4 hours 21 minutes (Australia New Zealand Trauma Registry, 2019).

State ambulance services operate around trauma activation protocols for hospital trauma teams. There is also a general model for the initial trauma admission under general surgery or a specific team in a trauma specialist model (i.e. surgeon or critical care specialty, emergency physician, anaesthetist, intensivist).

In NSW, Australia's most populous state, a rapid launch trauma coordinator scans the NSW ambulance computer-aided dispatch system to identify trauma cases that would benefit from early activation of an aeromedical response, for both metropolitan and rural/regional areas (Figure 1.6).

Of the patients who arrive alive, 15% die in the emergency department, with an overall mortality of 9.8% for those who are admitted. As a metric of trauma system performance, the median time from arrival to emergency department to computed tomography for patients with a Glasgow Coma Scale score below 13 was 45 minutes in 2018–2019. Median length of stay in hospital in severe trauma is 7.1 days, with a stay in intensive care of 3.8 days (Australia New Zealand Trauma Registry, 2019).

Several processes have evolved in response to the challenge of distance to streamline the process of haemorrhage control and improve haemostatic resuscitation. For example, in NSW a pre-hospital major haemorrhage protocol exists to coordinate the delivery of blood products to the scene for exsanguinating patients (Shand et al., 2021). Another initiative is the Code Crimson Pathway, which allows for the activation of hospital's major haemorrhage protocol, and operating theatre or interventional radiology staff from the pre-hospital environment by aeromedical teams treating patients with severe non-compressive haemorrhage. These patients are also often taken directly to the operating theatre/interventional radiology, bypassing the emergency department (NSW Institute of Trauma and Injury Management, 2017).

### Summary

The steps needed to create and manage a trauma system are complex and wide-ranging. It requires a combined multidisciplinary approach to protocol development plus a political willingness to



**Figure 1.6** Australian aeromedical scene response. Source: Courtesy of Troy Pearson.

meet the cost of the service. Time is essential to develop a coordinated and integrated plan appropriate to the geography of the area. The effort is, however, worthwhile. There is a growing evidence base to support the premise that trauma networks lead to significant improvements in outcomes. The chain of survival begins in the pre-hospital arena and ends with rehabilitation of the trauma victim. Each link in the chain needs to be strong as it can be with an continuing system for improvement. This book moves along the chain of trauma care, providing a comprehensive guide to current practice in trauma assessment and management. In doing so, it aims to allow the reader to understand and develop their own role in trauma care to its maximum potential.

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