The role of neurosciences intensive care in trauma and neurosurgical conditions

The creation of neurosciences intensive care units was born out of the awareness that a group of neurological and neurosurgical patients required specialized intensive medical and nursing care. This first of two articles describes the role of neurosciences intensive care in the management of trauma and neurosurgical conditions.

All general intensive care units in the UK look after patients with severe neurological illness. These may be patients with a primary neurological diagnosis or secondary neurological dysfunction caused by an underlying disease process or treatment. A snapshot audit conducted in 2006 suggested that more than 30% of patients with a primary neurosciences diagnosis were being managed in a general intensive care unit; the majority of these being patients with traumatic brain injury, defined as an alteration in brain function caused by an external force (M Smith, personal communication, 2006).

During the last 15–20 years, neurocritical care has evolved into a subspecialty in its own right. Whereas 20 years ago, most of these specialist units in the UK served primarily as recovery areas for patients that had undergone neurosurgery, they now focus on a wide range of conditions (*Table 1*). There are currently 21 specialist neurosciences critical care units in England with a total of 249 beds according to figures from the Department of Health (2011); a figure which falls short of recommendations from the Association of British Neurologists and the Society of British Neurological Surgeons (Bartlett et al, 1998; Association of British Neurologists, 2003). Of these, 116 are level 3 beds (intensive care) and 133 are level 2 (high dependency) beds. Although the total number of dedicated neurosciences intensive care beds is up by 20% over the last 5 years, the total number only represents 6% of all critical care beds nationally (M Smith, personal communication, 2006; Department of Health, 2011). With an occupancy rate greater than 90%, it is clear that these units play an essential role in the care of the patient with critical neurological illness (M Smith, personal communication, 2006).

Table 1. Neurosurgical conditions managed in the neurological intensive care unit

Traumatic brain injury
Traumatic spinal injury
Subarachnoid haemorrhage
Intracerebral haemorrhage
Postoperative neurosurgical patient

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Neurosurgical patients represent over 60% of all admissions to the neurosciences intensive care unit (Suarez, 2004). These patients can be broadly segregated into those who have sustained traumatic or non-traumatic brain or spinal cord injury and those requiring postoperative care. This article, the first of two, will address the role of neurosciences critical care in the management of traumatic and non-traumatic neurosurgical conditions, and the second article (p. 558) will cover neurological conditions.

Trauma admissions

There are at least 20 000 cases of major trauma each year in the UK which result in 5400 deaths (National Audit Office, 2010). The estimated annual lost economic output as a result of major trauma is £3.7 billion, with the cost of managing such cases within the NHS being approximately £0.5 billion (National Audit Office, 2010). Up to 80% of these patients will have sustained a traumatic brain injury (National Audit Office, 2010).

Traumatic brain injury

Traumatic brain injury remains the commonest cause of death in the under 40s. It accounts for 15–20% of deaths between the ages of 5 and 35 years (Jennett, 1996). The outcome from severe traumatic brain injury depends on the age of the patient, the severity and type of the initial injury and also the burden of secondary insults such as hypoxia, hypocapnia, hypotension and intracranial hypertension (Helmy et al, 2007). The principles of basic intensive care for patients with traumatic brain injury are shown in *Figure 1*. Data from the Trauma Audit and Research Network (TARN) in the UK show that management of a patient with a severe traumatic brain injury in a specialist centre results in a more than two-fold reduction in the odds of death compared to care in a non-neurosciences centre (Patel et al,

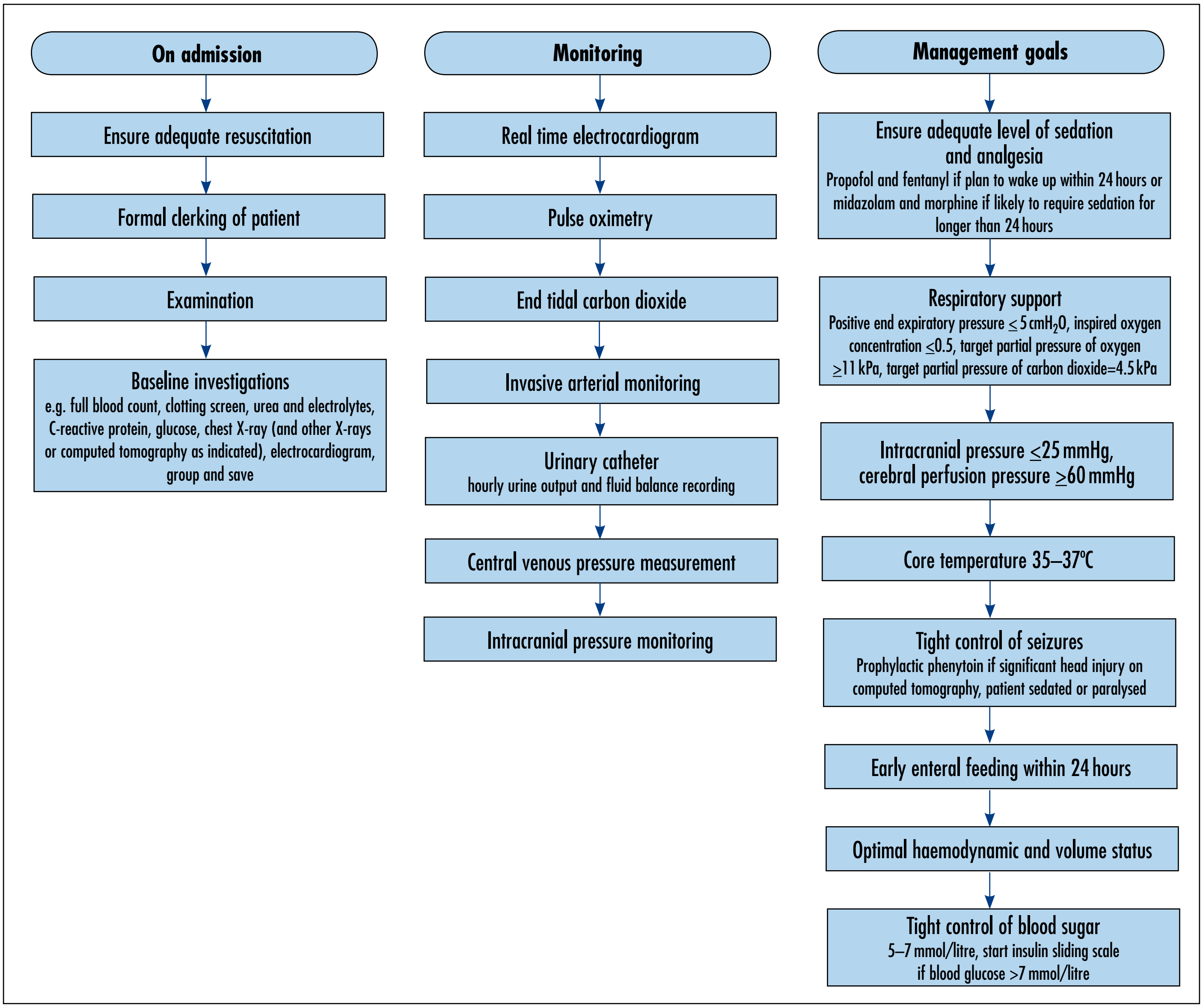

Figure 1. Principles of basic intensive care for patients with traumatic brain injury. Adapted from the Wessex Neurological Centre guidelines (www.neuroicu.org.uk).

2005). Presently, over 50% of cases are not managed in specialist centres (M Smith, personal communication, 2006; National Audit Office, 2010). Guidance from the National Institute for Clinical Excellence (NICE) now recommends that all patients with severe traumatic brain injury should be transferred to a neurosciences centre for management, including those without immediate need for neurosurgery (National Institute for Clinical Excellence, 2007). This recommendation has been questioned as the evidence cited has largely come from outside the UK and it would require an additional 84 000–105 000 bed days in specialist units (Perel et al, 2008; Barratt et al, 2010).

There are consensus guidelines for the management of traumatic brain injury (Briggs et al, 1984; Bartlett et al, 1998; Royal College of Surgeons of England Trauma Committee, 2005; Brain Trauma Foundation et al, 2007). Use of and adherence to protocols (*Figure 1*) is more widespread in specialized centres, has been shown to improve outcomes compared to historical controls and to be cost effective (Palmer et al, 2001; Fakhry et al, 2004; Faul et al, 2007; Farahvar et al, 2011b). Which component(s) of the protocols are particularly effective is not clear although individual therapies are now being subjected to clinical trials (Maas et al, 2008). What is clear is that a multidisciplinary team that cares regularly for patients with acute neurological illness is more likely to be aware of the importance of secondary insults and to prevent and manage these more aggressively (M Smith, personal communication, 2006; National Audit Office, 2010).

In addition, specialist centres are geared towards the monitoring of intracranial pressure and are therefore able to manage both intracranial pressure and cerebral perfusion pressure with a resultant reduction in morbidity and mortality (Farahvar et al, 2011a,b). Therapies such as insertion of ventriculostomies, intracranial pressure-targeted cooling and specialized monitoring such as brain tissue oxygenation, cerebral microdialysis and cerebral perfusion are also generally unavailable outside neurosciences centres (Marshall et al, 1979; Robertson et al, 1999; Czosnyka et al, 2005).

The provision of 24-hour onsite neurosurgical input at specialist centres means that definitive surgical management of refractory raised intracranial pressure through decompressive craniectomy is available when needed (Olivecrona et al, 2007; Weiner et al, 2010). The indications for this definitive procedure are presently a matter of debate, with evidence from the Early Decompressive Craniectomy in Patients with Severe Traumatic Brain Injury (DECRA) study demonstrating that early bifrontal decompressive craniectomy decreases intracranial pressure and length of stay in the neuro-intensive care unit but is associated with more unfavourable outcomes at 6 months (Cooper et al, 2011; Hempenstall et al, 2012). The lack of correlation between the decrease in intracranial pressure following decompressive craniectomy and improvement in outcome has raised many questions regarding the findings of the DECRA study (Hempenstall et al, 2012). These questions are being addressed by the ongoing Randomised Evaluation of Surgery with Craniectomy for Uncontrollable Elevation of Intracranial Pressure (RESCUE-ICP) trial and the results of this should more clearly define the indications and outcomes for decompressive craniectomy (Hutchinson et al, 2006).

Traumatic spinal injury

In 2000–1, there were 2005 cervical spine fractures in England with 607 spinal cord injuries at all levels (Tan et al, 2005). Isolated cervical spine injuries make up approximately 37% of all spinal injuries and 50% of these are likely to be associated with neurological injury (Tan et al, 2005). The vast majority of traumatic spinal injuries are the result of a fall from height. In contrast, cervical spine injuries are more common following road traffic accidents and are associated with an increased risk of mortality (Tan et al, 2005). The distribution of traumatic spinal injury is bimodal, with peaks in young adults and in those over 60 years of age.

The pathophysiology of traumatic spinal injury is complex and multifaceted. It can be divided into a non-reversible component – the primary injury which refers to damage to the anatomical components of the spinal cord as a result of shear forces at the moment of trauma, and a reversible component – the secondary injury as a result of the inflammatory cellular cascade immediately after the trauma (Cadotte and Fehlings, 2011). Like traumatic brain injury, management of traumatic spinal injury is focused on ameliorating the effects of secondary damage.

Comprehensive evidence-based guidelines, produced by the Congress of Neurological Surgeons of the USA, have been in place for nearly 10 years outlining the management of acute cervical spine and spinal cord injuries (Hadley, 2002a). These address not only the surgical management of the injury (Hadley, 2002c,d) but also the critical care components (Hadley, 2002b). Many patients with spinal cord injury require intensive care either as a result of direct respiratory compromise or as a result of associated injuries (Tan et al, 2005). The spinal cord is as susceptible as the brain to secondary injury (systemic hypotension, hypoxia, hyperpyrexia and hypocapnia) and several reports have shown improvement in patient management and outcome after spinal cord injury with the use of protocols and aggressive medical management (Gschaedler et al, 1979; Hadley, 2002b; Tan et al, 2005). Recommendations include maintenance of mean arterial pressure at 85–90 mmHg for at least 7 days after acute injury, early nutritional support and deep venous thrombosis prophylaxis.

The value of early surgical management *vs* late or no surgical intervention for complete spinal cord injuries has been questioned (Hadley, 2002a; El Masri, 2010; Cadotte and Fehlings, 2011). Although nationally about 80% of acute spinal cord injuries are managed surgically (with decompression of the cord and spinal stabilization), this figure is as low as 15% in some institutions (Tan et al, 2005). Most vertebral fractures will heal within 6–12 weeks of injury and the majority will become mechanically stable and pain free. Encroachment into the spinal canal or cord compression do not appear to affect the degree of recovery as the vast majority of injury has already occurred. The use of clinical prediction tools to clarify prognosis following injury in specialist centres may also be central in the stratification of patients to tailor specialist management (van Middendorp et al, 2011).

Non-traumatic admissions

The remainder of admissions to the neurosciences intensive care unit are primarily as a result of spontaneous intracerebral haemorrhage or subarachnoid haemorrhage, infections affecting the spinal cord and those related to postoperative care of the neurosurgical patient.

Intracerebral haemorrhage

Intracerebral haemorrhage accounts for 10–30% of all stroke admissions to hospital and has a 6-month mortality close to 50% (Mayer and Rincon, 2005). Those who survive are often left with severe disability. Management of intracerebral haemorrhage is presently limited to guidelines regarding blood pressure optimization, intracranial pressure monitoring, fluid resuscitation, seizure prophylaxis and care in a specialized unit (Mayer and Rincon, 2005).

The largest set of guidelines to date has been developed by the joint American Heart, Stroke and Blood

Associations (Broderick et al, 2007; Morgenstern et al, 2010). Review of these guidelines has demonstrated that apart from management in a specialized stroke unit or neurosciences intensive care unit, no specific medical therapies have been shown to consistently improve outcome following intracerebral haemorrhage (Rincon and Mayer, 2008). Surgical intervention following spontaneous intracerebral haemorrhage remains a matter of increasing investigation and debate (Mendelow and Unterberg, 2007; Adeoye et al, 2010). The Surgical Trial in Intracerebral Haemorrhage (STICH) is the largest published trial to date (1033 randomized patients) and has demonstrated that there is no overall benefit from early surgery when compared to initial conservative treatment for all patients (Mendelow et al, 2005). More recently, smaller studies have come out in favour of surgery in cases of superficial spontaneous cerebral haemorrhages (Hattori et al, 2006; Mendelow and Unterberg, 2007). This has prompted new recommendations from the European Stroke Initiative for surgical intervention in superficial haematomas (Steiner et al, 2006). What is clear from all studies is that patient admission to a neurosciences intensive care unit is the only significant factor in influencing outcome and prognosis (Diringer and Edwards, 2001; Hemphill et al, 2004; Gebel, 2012).

Subarachnoid haemorrhage

Subarachnoid haemorrhage represents a small percentage (approximately 3–5%) of the total number of strokes (van Gijn and Rinkel, 2001; M Smith, personal communication, 2006) and has an incidence of 10 per 100 000 in the UK population per year (Pobereskin, 2001a). Mortality is significant, exceeding 40% in many studies, with many survivors remaining disabled even with optimal treatment (Hop et al, 1997; Pobereskin, 2001a,b; Coppadoro and Citerio, 2011). As most patients are under the age of 60 years, it has a profound societal effect. The causes of subarachnoid haemorrhage are shown in *Table 2*. Modifiable risk factors for aneurysmal haemorrhage include smoking, hypertension, heavy drinking and cocaine abuse.

There exist several classifications systems for subarachnoid haemorrhage based on presenting Glasgow Coma Score, blood load/distribution and the presence of focal neurological deficit (Rosen and Macdonald, 2005; Highton and Smith, 2013). However, the Glasgow Coma Score and patient's age remain the greatest prognostic predictors to date (Lagares et al, 2001; St Julien et al, 2008).

Around 10–20% of patients with subarachnoid haemorrhage are comatose on arrival at hospital and require immediate intubation. If clinical signs of acute coning are absent, such patients should be observed initially for 24 hours for clinical signs of improvement. If repeated computed tomography scans show signs of ventricular enlargement or if conscious levels improve after withdrawal of sedation, consideration should be given to transfer to specialist care. Specialist neurosciences intensive care may be required before surgical or endovascular securing of the aneurysm because of the severity of the haemorrhage or the presence of associated cardiorespiratory dysfunction. In this early phase, management in a neurosciences intensive care unit is centred around the prevention of rebleeding, treating hydrocephalus and elevated intracranial pressure, systemic monitoring and treatment of early physiological derangements (Coppadoro and Citerio, 2011) (*Figure 2*). Numerous

Table 2. Aetiology of subarachnoid haemorrhage

Intracranial aneurysmal bleed (85%)
Arteriovenous malformation (10%)
Non-aneurysmal perimesencephalic haemorrhage
Septic (mycotic) aneurysm rupture
Moyamoya syndrome
Coagulopathy
Extension of an intracerebral haematoma

Figure 2. Aetiology of patient deterioration following subarachnoid haemorrhage. Adapted from the Wessex Neurological Centre guidelines (www.neuroicu.org.uk).

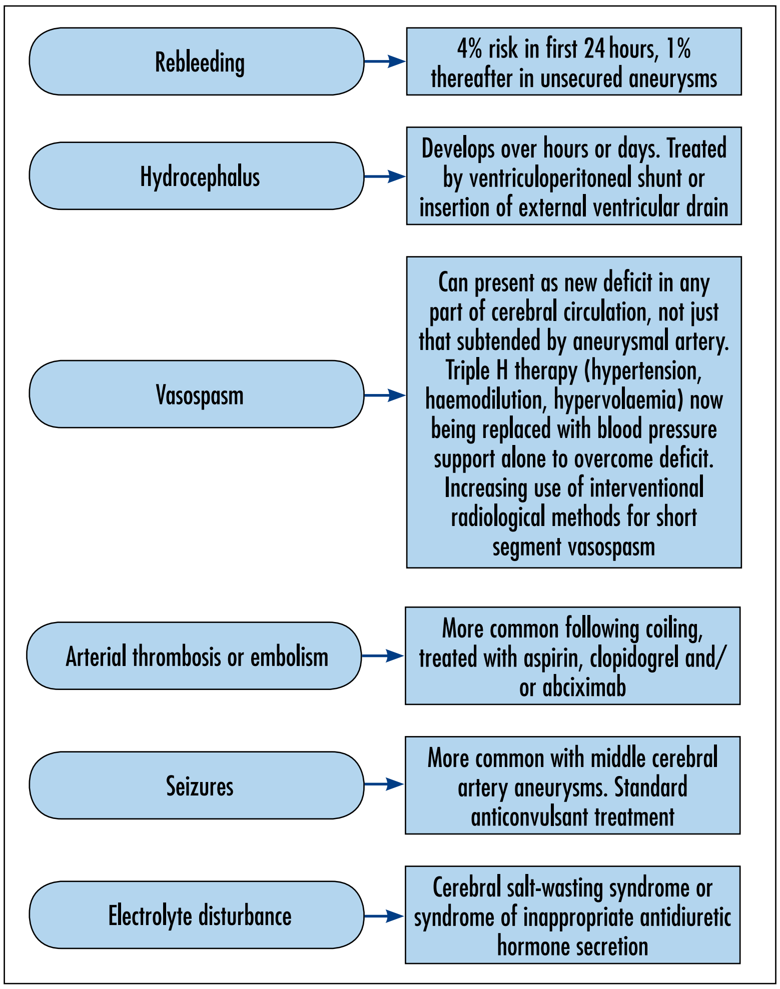

Table 3. Aetiology of neurosurgical postoperative admission to neurological intensive care unit

Long operation
Extensive blood losses
Overnight ventilation to ensure stability
Haemodynamic monitoring
Seizure activity
Preoperative medical problems

studies have demonstrated that specialist care improves outcomes for patients with atraumatic subarachnoid haemorrhage (Mirski et al, 2001; Suarez et al, 2004; Samuels et al, 2011). The evidence demonstrates a significant reduction of in-hospital mortality compared with a similar group of patients managed under the care of general intensivists. In particular, patients treated by a multidisciplinary neurocritical care team were significantly more likely to be discharged home and were significantly less likely to be discharged to a rehabilitation facility than those treated by a general intensive care team (Hlavin et al, 1990; Khanna et al, 1996; Tompkins et al, 2010; Samuels et al, 2011).

Postoperative neurosurgical care

Following neurosurgery, the aim for all patients is the detection and prevention of neurological deterioration while supporting systemic homeostasis. In many cases this postoperative period is short and uneventful, and does not warrant admission to neurosciences intensive care unit (Pritchard, 2008). However, some cases will require postoperative monitoring and support following surgery (*Table 3*).

Conclusions

The neurosciences intensive care unit plays a significant role in the management of trauma and neurosurgical patients. There is a growing body of evidence to suggest that patients admitted to specialist units have significantly better outcomes as a result of specialist monitoring and input from the neurosciences multidisciplinary team. With bed occupancy running at over 90% these units are invaluable in the management of complex neurosurgical and neurological patients. A national drive to increase the capacity of these units should result in better patient outcomes and reduced societal cost. **BJHM**

Conflict of interest: none.

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KEY POINTS

- The outcomes from severe traumatic brain injury, spinal cord injury, intracerebral haemorrhage and subarachnoid haemorrhage have all been shown to be improved by care in specialist neurosciences intensive care units.
- Patients with severe brain or spinal injuries that do not require neurosurgical intervention also benefit from care in specialist neurosciences intensive care units.
- Which component(s) of care are particularly important is not clear but earlier recognition and management of secondary insults is essential.

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