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Paul A. Nyquist, Marek A. Mirski, and Rafael J. Tamargo

**Moderate and Severe Traumatic Brain Injury: Pathophysiology and Management** **309**

Anthony R. Frattalone and Geoffrey S.F. Ling

Traumatic brain injury (TBI) is a serious disorder that is all too common. TBI ranges in severity from mild concussion to a severe life-threatening state. Across this spectrum, rational therapeutic approaches exist. Early identification that TBI has occurred in a patient is paramount to optimal outcome. Proper clinical management should be instituted as soon as possible by appropriately trained medical providers. More seriously injured patients must be triaged to advanced care centers. It is only through this rational approach to TBI that patients may expect to achieve optimal clinical and functional outcome.

**Managing Subarachnoid Hemorrhage in the Neurocritical Care Unit** **321**

Justin M. Caplan, Geoffrey P. Colby, Alexander L. Coon, Judy Huang, and Rafael J. Tamargo

Patients with aneurysmal subarachnoid hemorrhage who survive the initial hemorrhage require complex interventions to occlude the aneurysm, typically followed by a prolonged intensive care unit and hospital course to manage the complications that follow. Much of the morbidity and mortality from this disease happens in delayed fashion in the neurocritical care unit. Despite progress made in the last decades, much remains to be understood about this disease and how to best manage these patients. This article provides a review of current evidence and the authors' experience, aimed at providing practical aid to those caring for patients with this disease.

**Management of Acute Spinal Cord Injury in the Neurocritical Care Unit** **339**

Linton T. Evans, Stuart Scott Lollis, and Perry A. Ball

Acute spinal cord injury (SCI) is associated with widespread disturbances not only affecting neurologic function but also leading to hemodynamic instability and respiratory failure. Traumatic SCI rarely occurs in isolation, and frequently is accompanied by trauma to other organ systems. Management of individuals with SCI is complex, requiring aggressive monitoring and prompt treatment when complications arise. Typically this level of care is provided in the neurocritical care unit. This article reviews the pathophysiology of the neurologic, cardiovascular, and pulmonary derangements following traumatic SCI and their management in the critical care setting.

**Intracerebral Hemorrhage: New Challenges and Steps Forward** **349**

Jose Javier Provencio, Ivan Rocha Ferreira Da Silva, and Edward Michael Manno

Intracerebral hemorrhage (ICH) is a significant cause of morbidity and mortality. With the aging population, increased use of anticoagulants, and changing racial and ethnic landscape of the United States, the incidence of ICH will increase over the next decade. Improvements in preventative strategies to treat hypertension and atrial fibrillation are necessary to change the trajectory of this increase. Advances

in the understanding of ICH at the vascular and molecular level may pave the way to new treatment options. This article discusses the epidemiology, pathophysiology, and current treatment options for patients with ICH. Differences in outcome and treatment between patients taking and not taking anticoagulant therapies are considered.

### **Management of Intracerebral Pressure in the Neurosciences Critical Care Unit**

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Scott A. Marshall, Atul Kalanuria, Manjunath Markandaya, and Paul A. Nyquist

Management of intracranial pressure in neurocritical care remains a potentially valuable target for improvements in therapy and patient outcomes. Surrogate markers of increased intracranial pressure, invasive monitors, and standard therapy, as well as promising new approaches to improve cerebral compliance are discussed, and a current review of the literature addressing this metric in neuroscience critical care is provided.

### **Surgical Treatment of Elevated Intracranial Pressure: Decompressive Craniectomy and Intracranial Pressure Monitoring**

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Tarek Y. El Ahmadieh, Joseph G. Adel, Najib E. El Tecle, Marc R. Daou, Salah G. Aoun, Allan D. Nanney III, and Bernard R. Bendok

Surgical techniques that address elevated intracranial pressure include (1) intraventricular catheter insertion and cerebrospinal fluid drainage, (2) removal of an intracranial space-occupying lesion, and (3) decompressive craniectomy. This review discusses the role of surgery in the management of elevated intracranial pressure, with special focus on intraventricular catheter placement and decompressive craniectomy. The techniques and potential complications of each procedure are described, and the existing evidence regarding the impact of these procedures on patient outcome is reviewed. Surgical management of mass lesions and ischemic or hemorrhagic stroke occurring in the posterior fossa is not discussed herein.

### **Seizures and the Neurosurgical Intensive Care Unit**

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Panayiotis N. Varelas, Marianna V. Spanaki, and Marek A. Mirski

The cause of seizures in the neurosurgical intensive care unit (NICU) can be categorized as emanating from either a primary brain pathology or from physiologic derangements of critical care illness. Patients are typically treated with parenteral antiepileptic drugs. For early onset ICU seizures that are easily controlled, data support limited treatment. Late seizures have a more ominous risk for subsequent epilepsy and should be treated for extended periods of time or indefinitely. This review ends by examining the treatment algorithms for simple seizures and status epilepticus and the role newer antiepileptic use can play in the NICU.

### **Strategies for the Use of Mechanical Ventilation in the Neurologic Intensive Care Unit**

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Wan-Tsu W. Chang and Paul A. Nyquist

Mechanical ventilation in neurologically injured patients presents unique challenges. Patients with acute neurologic injuries may require mechanical ventilation for reasons beyond respiratory failure. There is also a subset of pulmonary pathologic abnormality directly associated with neurologic injuries. Balancing the need to maintain brain oxygenation, cerebral perfusion, and control of intracranial pressure can be in conflict with concurrent ventilator strategies aimed at lung protection. Weaning and

liberation from mechanical ventilation also require special considerations. These issues are examined in the ventilator management of the neurologically injured patient.

### **Microdialysis in the Neurocritical Care Unit**

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Ryan Kitagawa, Shoji Yokobori, Anna T. Mazzeo, and Ross Bullock

Effective monitoring is critical for neurologically compromised patients, and several techniques are available. One of these tools, cerebral microdialysis (MD), was designed to detect derangements in cerebral metabolism. Although this monitoring device began as a research instrument, favorable results and utility have broadened its clinical applications. Combined with other brain monitoring techniques, MD can be used to estimate cerebral vulnerability, to assess tissue outcome, and possibly to prevent secondary ischemic injury by guiding therapy. This article reviews the literature regarding the past, present, and future uses of MD along with its advantages and disadvantages in the intensive care unit setting.

### **Parenchymal Brain Oxygen Monitoring in the Neurocritical Care Unit**

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Peter D. Le Roux and Mauro Oddo

Patients admitted to the neurocritical care unit (NCCU) often have serious conditions that can be associated with high morbidity and mortality. Pharmacologic agents or neuroprotectants have disappointed in the clinical environment. Current NCCU management therefore is directed toward identification, prevention, and treatment of secondary cerebral insults that evolve over time and are known to aggravate outcome. This strategy is based on a variety of monitoring techniques including use of intraparenchymal monitors. This article reviews parenchymal brain oxygen monitors, including the available technologies, practical aspects of use, the physiologic rationale behind their use, and patient management based on brain oxygen.

### **Use of Transcranial Doppler (TCD) Ultrasound in the Neurocritical Care Unit**

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Atul Kalanuria, Paul A. Nyquist, Rocco A. Armonda, and Alexander Razumovsky

Transcranial Doppler (TCD) is a portable device that uses a handheld 2-MHz transducer. It is most commonly used in subarachnoid hemorrhage where cerebral blood flow velocities in major intracranial blood vessels are measured to detect vasospasm in the first 2 to 3 weeks. TCD is used to detect vasospasm in traumatic brain injury and post-tumor resection, measurement of cerebral autoregulation and cerebrovascular reactivity, diagnosis of acute arterial occlusions in stroke, screening for patent foramen ovale and monitoring of emboli. It can be used to detect abnormally high intracranial pressure and for confirmation of total cerebral circulatory arrest in brain death.

### **Hypothermia in Neurocritical Care**

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Neeraj Badjatia

Hypothermia has long been recognized as an effective therapy for acute neurologic injury. Recent advances in bedside technology and greater understanding of thermoregulatory mechanisms have made this therapy readily available at the bedside. Critical care management of the hypothermic patient can be divided into 3 phases: induction, maintenance, and rewarming. Each phase has known complications that require careful monitoring. At present, hypothermia has only been shown to be an

effective neuroprotective therapy in cardiac arrest survivors. The primary use of hypothermia in the neurocritical care unit is to treat increased intracranial pressure.

**Assessment of Brain Death in the Neurocritical Care Unit** **469**

David Y. Hwang, Emily J. Gilmore, and David M. Greer

This article reviews current guidelines for death by neurologic criteria and addresses topics relevant to the determination of brain death in the intensive care unit. The history of brain death as a concept leads into a discussion of the evolution of practice parameters, focusing on the most recent 2010 update from the American Academy of Neurology and the practice variability that exists worldwide. Proper transition from brain death determination to possible organ donation is reviewed. This review concludes with a discussion regarding ethical and religious concerns and suggestions on how families of patients who may be brain dead might be optimally approached.

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