1

Introduction

The Practice of Neurocritical Care

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> "Good judgment is the result of experience and experience the result of bad judgment." – Mark Twain

Intensive care units exist for patients with severe disease, as well as for patients who are expected to be unstable. Unprovoked changes to vital signs, neurological examinations, laboratory results, and imaging are expected in such patients, although some events can be anticipated, rescued, or salvaged. One should know what comes next, how to communicate what has happened, and what is likely to happen next.

Being responsible for a neurological intensive care unit without knowledge and/or experience should provoke anxiety. This handbook is intended to improve your judgment from the experience of others. Each chapter has been authored by an expert in the field. We do not imply that there is no other way to manage neurologically critically ill patients, but only that this is one expert way to do so. Others may argue that there are better ways to manage specific problems, and, on occasion, it will be correct. However, the authors believe this book will not disappoint the clinicians in search of new knowledge, a refresher, and options.

Each chapter covers a crucial topic in neurological critical care (NCC). This does not mean this volume is exhaustive – there is always another topic that could benefit from its own explanation, another decision tree,

and a refined protocol. Of note, this volume broadly excludes ischemic stroke, which is covered by another volume in this series. Exhaustion, however, is not the point. You need to know what to do in this shift on behalf of the patient and how to defend your actions the next time you round.

Blood pressure, temperature, heart rate, and respiratory rate are the classical vital signs. For patients with severe neurological disease, intracranial pressure (ICP) could be considered a fifth vital sign. Recognition and management of abnormal ICP are as important as managing the other vital signs and cannot take place without managing other vital signs. Dr. Stephan Mayer leads the reader through ICP interpretation and management, bringing a perspective honed over decades as a leading authority in the field.

Temperature dysregulation is common in NCC. Delicate neurologic mechanisms that are intended to maintain a normal temperature are frequently disturbed after severe neurological injury. Abnormal temperature is a consequence of neurologic injury, and it can make existing neurologic injury worse. However, some treatments of temperature dysregulation can be ineffective or worse. Understanding temperature dysregulation is important to interpret, predict, and manage temperature. Dr. Ameeta Karmarkar reviews the pathophysiology needed to understand temperature dysregulation and its effective management.

NCC is imaging-intensive. A working knowledge of neuroradiology is essential to diagnose, anticipate, and manage NCC patients. Neurologic diagnosis and management for both hemorrhagic (subarachnoid hemorrhage and intracerebral hemorrhage) and ischemic (particularly acute vessel occlusion) patients are authoritatively reviewed, led by Drs. Nemeth and Russell.

Critical care often comes with a need for a mechanical ventilator. Unfortunately, training in respiratory medicine is not always sufficient before starting in neurocritical care. Fortunately, Dr. Howard Lee provides

instruction regarding management of the airway, oxygen, and mechanical ventilator.

Drug therapy for NCC is sometimes similar to that of other intensive care settings (e.g., antibiotics for sepsis) but is often peculiar to neurologic disease. Seizure medications, hypertonic fluids, and vasopressors to induce hypertension are uncommonly seen outside of a neurological intensive care unit. Like other intensive care units, a pharmacist is a strategic resource. Dr. Deepika McConnell reviews how to most effectively work with the most commonly used medications and the pharmacist, if you are fortunate enough to have one as a colleague. If you do not have a dedicated pharmacist, Dr. McConnell's level of expertise may help you convince your institution that the pharmacist is a crucial resource for patient care.

Intracerebral hemorrhage, bleeding into brain tissue, is the most morbid form of stroke. Early diagnosis and management of intracerebral hemorrhage can be lifesaving. Some patients require an acute therapy (e.g., blood pressure reduction, reversal of anticoagulant medication). Most patients require critical care management, which reduces complications and prepares the patient for the next phase of care (e.g., rehabilitation, nursing facility). Dr. Brandon Francis, a retired officer and a gentleman, reviews management of intracerebral hemorrhage.

Coagulopathy increases the likelihood of bleeding. Bleeding in the nervous system can quickly lead to permanent disability or death. Coagulopathy is complicated to measure once one gets beyond the prothrombin time and international normalized ratio. The diagnosis and management of coagulopathy are crucial to preventing death and disability in NCC. Dr. Tiffany Chang reviews measures of coagulation and how to correct disorders in the activation of coagulation, thrombosis, and fibrinolysis.

Subarachnoid hemorrhage, ruptured intracranial aneurysm, presents an unusual challenge. Typically, therapies for stroke are rescue therapies,

for example, fibrinolysis after ischemic stroke. Patients with subarachnoid hemorrhage, however, may have two acute neurological changes. The first occurs at the time of aneurysmal rupture, and the second occurs about a week later with the heralding of symptomatic vasospasm. Dr. Alex Choi guides you through the diagnosis and management of subarachnoid hemorrhage.

Subdural hematoma has received less attention than intracerebral hemorrhage or subarachnoid hemorrhage. Yet, subdural hematomas will become more and more commonplace in an aging America that uses more anticoagulant medications for the prevention of vascular disease. Unlike intracerebral hemorrhage, subarachnoid hemorrhage, or neurotrauma, subdural hematoma has no grading scale, guidelines from randomized trials, or specifically approved treatment. Dr. Peter Pruitt fills the void on the diagnosis, assessment, and management of subdural hematoma.

Seizures and status epilepticus may occur without a precipitating condition and are a common complication of other neurological conditions, particularly intracranial hemorrhage or trauma. The longer seizures last, the worse the patient's outcome will be, so obliterating seizures quickly is crucial to maximizing patient outcomes. Dr. Swor reviews the management of status epilepticus in an intensive care setting.

Neurocritical Care takes place outside of dedicated neurologic units. Neurointensivists may be asked to provide consultation to evaluate coma and the likelihood of neurological recovery after coma generally, and cardiac arrest specifically. This condition has a long history of evaluation, complications (particularly myoclonic seizures), and prognosis. Drs. Braksick and Rabinstein update you on how to effectively evaluate and prognosticate after coma.

Many decisions will be yours to make; however, some of the most important decisions should be made in consultation. Decisions about goals of care, life-sustaining procedures (gastrostomy, tracheostomy), and

do-not-resuscitate status should ideally involve the patient and/or a surrogate decision-maker. These conversations are often difficult, multilayered, and emotionally laden. Dr. Susanne Muehlschlegel, an expert in surrogate decision-making in NCC, leads you through best practices for these difficult conversations.

My colleagues and I have worked hard to compile this volume. We hope you find it useful and will share your feedback with us.