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Critical Care in Neurology: A Review of Literature

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Abstract

Intensive care takes care of very severe, mostly acutely ill people. Such patients are best treated in intensive care units with experienced staff and appropriate facilities. Some hospitals have special units for specific patients, e.g., cardiac, surgical, neurological, pediatric, neonatal. This paper discusses intensive care in neurology. The aim of this paper is to briefly describe the issues that medical professionals in the field of intensive care face on a daily basis. Regardless of the health status of patients, medical professionals from the intensive care unit of any hospital in the world must make great efforts to provide them with quality medical care.

INTRODUCTION

Management of critically ill patients relies heavily on continuous cardiac and respiratory monitoring; however, continuous neurologic monitoring is not the standard of care for most intensive care unit (ICU) patients [1]. It can be difficult to monitor neurologic fluctuations in ICU patients that are frequently sedated as well as those with an impaired level of consciousness due to brain injury. Imaging studies like computed tomography (CT), magnetic resonance imaging (MRI), and Doppler ultrasound, provide only a snapshot in time. Continuous monitors are necessary to capture the minute-to-minute physiologic changes that impact patient outcome. Neurophysiological techniques such as electroencephalography (EEG) provide the ability to continuously monitor the brain at the bedside. Medication effects, diurnal variations in level of consciousness or state changes, and structural lesions add to the variability of the data obtained and necessitate contextual interpretation of EEG. Issues of practicality include cost of machinery, maintenance of high-quality recordings, identification of ICU inherent artifacts, nonspecificity of findings, controversial observations, and time-consuming interpretation. However, continuous EEG (cEEG) enables diagnostic and monitoring information that would otherwise not be available [1].

Caring for patients in the neurosciences critical care unit (NCCU) requires consistent and conscientious application of important ethical principles and an understanding of the law concerning surrogate decision making [2]. The vast majority of patients lack decision-making capacity due to coma, aphasia, delirium, or other alterations of consciousness, and therefore decisions regarding their treatment and care must be made by surrogates. In addition, many NCCU patients have uncertain prognoses that will influence the type of treatments offered by the NCCU team, and the types of decisions made by the surrogates.

Intracranial pressure (ICP)

The roles of intracranial pressure (ICP) monitoring and control are both unique and vital to neurocritical care [3]. When ICP rises above safe thresholds, serious consequences can ensue. As ICP rises, it decreases cerebral perfusion pressure (CPP) and may decrease cerebral blood flow (CBF) if not compensated by the intrinsic autoregulatory capacity of the brain. Additionally, persistent ICP elevations or pressure gradients bear the risk of tissue herniation and subsequent neurologic decline. Maintaining an appropriate ICP is a therapeutic principle for critical neurologically injured patients. While radiologic imaging and clinical examination of the patient can provide valuable insight regarding ICP status, ICP monitoring is required for definitive measurement and continuous tracking of this monitoring parameter.

The decision to place an invasive ICP monitor requires careful consideration, as it carries its own set of inherent risks. Furthermore, there has been recent debate regarding the appropriate indications for ICP monitoring as well as the role of ICP monitoring in improved clinical outcomes. Numerous noninvasive modalities have also been studied, including CT/MRI scans, fundoscopy, tympanic membrane displacement and transcranial Doppler, yet none have proven superior or as reliable as invasive monitoring. Despite its invasive nature, ICP monitoring via ventriculostomy has remained the gold standard for accurate measurement of ICP. Noninvasive modalities still have a place in the neurocritical care setting, as they provide further information regarding the patient's overall neurologic well-being. This chapter focuses on the invasive monitors of ICP. For critically ill brain-injured patients, ICP monitoring allows care to be tailored and individualized to meet the unique needs of the neurological or neurosurgical critical care patient [3].

Transcranial Doppler (TCD)

TCD has been increasingly utilized as a monitoring tool in the neurocritical care unit (NCCU) because it is a noninvasive tool and can be brought to the bedside [4].

The number one indication for TCD in the NCCU is the detection and monitoring of vasospasm (VSP) in patients with aneurysmal and traumatic subarachnoid hemorrhage (SAH). In addition, TCD is being studied as a noninvasive estimator of intracranial pressure (ICP) and cerebral perfusion pressure (CPP) in patients with severe traumatic brain injury (TBI). In addition, TCD has been utilized as a monitoring tool for detection of microembolic signals in the presence of acute ischemic stroke. Finally, TCD has been extensively studied in the setting of clinical brain death.

Over the past decade, Power M-Mode TCD, transcranial color coded duplex, and the use of contrast agents have extended the utility of TCD in the NCCU to include indications such as monitoring of arterial occlusion in acute ischemic stroke and detection of microembolic signals in carotid stenosis and cardioemboli disease.

TCD is a noninvasive, bedside, transcranial US method of determining flow velocities in the basal cerebral arteries. When using a range-gated Doppler US instrument, placement of the probe in the temporal area just above the zygomatic arch allows the velocities in the middle cerebral artery (MCA) to be determined from the Doppler signals. The flow velocities in the proximal anterior (ACA), terminal intracranial artery (tICA) and posterior (PCA) cerebral arteries can be recorded at steady state and during test compression of the common carotid arteries [4].

Brain Injury

Neurosurgical critical care covers a wide array of disorders with varying pathophysiologic features [5]. These conditions also may be associated with unique complications that must be recognized and treated promptly. Physicians involved in the ICU management of neurosurgical patients therefore must be familiar with the clinical features, complications, and treatment of CSN disorders.

By definition, primary traumatic brain injury occurs at the time of impact. This may lead to irreversible damage from cell disruption depending on the mechanism and severity of the inciting event. Head trauma may cause damage to the scalp, skull, and underlying brain. Scalp lacerations can cause significant hemorrhage, but in most cases hemostasis can be achieved easily. Fractures are classified as linear, depressed, compound, or involving the skull base. Linear or simple skull fractures require no specific treatment. Depressed skull fracture occurs when the outer table of the skull is depressed below the inner table and may result in tearing of the dura or laceration of the brain. Operative repair may be required, especially if the depressed fracture involves the posterior wall of the frontal sinus or is associated with intracranial hematoma. Compound depressed fractures are defined as those associated with laceration of the overlying scalp and are treated by surgical wound debridement and fracture elevation, if severe. Basal skull fractures, which may be diagnosed by the clinical findings of periorbital ecchymosis ("raccoon eyes"), ecchymosis of the postauricular area (Battle's sign), hemotympanum, or cerebrospinal fluid (CSF) leak, may be complicated by meningitis or brain abscess. Patients suffering from skull fractures have an increased risk of delayed intracranial hematoma and should be observed for 12–24 hours after the initial injury.

Brain injury can occur directly under the injury site (coup injury), but because the brain may move relative to the skull and dura, compression of the brain remote from the site of impact also can occur. This explains why brain injury can occur in intracranial regions opposite the point of impact (contrecoup injury). Craniocerebral trauma can cause concussion, cerebral contusion, intracranial hemorrhage, or diffuse axonal injury [5].

The blood–brain barrier (BBB)

BBB isolates the brain from variations in body fluid composition, thereby providing a stable environment for neural–neural and neural–glial interactions [6]. It does this by first acting as an ionic and molecular sieve through its involvement in ionic transport and selective transport of small molecules and proteins. Large molecules, polar molecules are generally excluded by the BBB except for metabolically important molecules such as glucose, amino acids, lactate, and neurotransmitter precursors. The movement of these molecules into the CBF depends on special transport mechanisms. For example, the movement of glucose depends on the transporter GLUT-1. During times of stress, such as hypoglycemia, the BBB has been shown to have adaptive responses to a changing metabolic environment by increasing the transport of lactate and ketone bodies into the CBF. Second, the endothelial cells contain a host of enzymes that protect the brain from circulating neurochemicals and toxins. For example, amino acid decarboxylase (MAO), pseudocholinesterase, γ-aminobutyric acid (GABA) transaminase, aminopeptidases, and alkaline phosphatase are present in the brain capillaries. This prevents the unrestricted entry of potential toxins into the brain.

Patients

If the patient is conscious they will have high psychological needs: they may experience varying degrees of anxiety, stress, pain and disorientation [7]. The practitioner will need to be aware that, although there is a vast volume of work to do in the initial phase of admission, the priority to the patient is reassurance and information. It cannot be stressed enough that the patient must be informed and consent to all procedures and investigations. If the patient is unconscious then the practitioner may still be able to communicate with the patient through touch and speech – it is well documented that hearing is the last sense to go.

On admission to the critical care unit, the patient will receive a more detailed examination than was conducted within the emergency department, as time will be able to be spent on a detailed neurological examination and evaluation. One of the main assessments on arrival to the unit is whether the patient's neurological status has improved or deteriorated during the transfer from the A&E department [7].

Mental Status

The complexity of the brain renders its normal functioning, especially the production of consciousness, uniquely vulnerable to acute metabolic derangements and structural deformation [8]. As a perpetual glucose and oxygen glutton, the brain is extremely intolerant of sudden changes in energy homeostasis and in vivo neurons begin to die after only minutes of fuel deprivation. Likewise, the diffuse circuitry responsible for consciousness in the brain makes anatomic insults involving both cerebral hemispheres and the brainstem reticular activating system necessary and suffi cient to perturb mental status. Regardless of etiology, altered mental status (AMS) or brain failure frequently prolongs hospital length of stay and worsens the prognosis of patients in the critical care setting. Rapid diagnosis is necessary to differentiate imminently life-threatening brain failure from more benign, reversible forms. As an amalgam of evidence-based practice and our clinical experience, this chapter will focus on the diagnostic and management challenges of AMS in the intensive care unit (ICU).

Mental status forms the core of any neurologic examination. Caregivers at all levels should be trained to abandon labeling a patient "unresponsive" in favor of more descriptive categories based on the physical examination: lethargy, obtundation, stupor, and coma. Lethargic patients manifest decreased alertness but retain awareness of their environment. Obtunded patients require a stimulus to rouse and follow simple commands but have lost awareness of their immediate surroundings. Stuporous patients do not follow commands and require a continuous painful stimulus to exhibit signs of arousal. Finally, comatose patients exhibit no awareness and no significant arousal response to even painful stimuli. Coma results from bilateral cerebral hemisphere impairment or dysfunction of the reticular activating system in the brainstem; unilateral hemispheric disease (such as a middle cerebral artery stroke) does not typically lead to coma unless there is associated midline shift and resultant contralateral hemispheric dysfunction. Although these categories are useful to help qualitatively describe the level of depressed consciousness in a patient, the lack of standardized defi nitions for these terms makes them prone to misuse and variable interpretation.

Any particular intervention for AMS will be dependent upon the disease process [9]. Processes that cause anatomical derangement should be managed in an emergent fashion. Subdural hematomas, epidural hematomas, contusions, and the like, are all disease processes that, if severe enough, will require emergent surgical intervention. A seizure will require anticonvulsant therapy, and if prolonged, in the case of status epilepticus or multiple seizures, may require emergent benzodiazepines. Cerebrovascular accidents of the ischemic type may be treated with clot-busting drugs or other interventional techniques if the time period is within certain guidelines. A large middle cerebral artery territory ischemic stroke may require a lifesaving decompressive craniectomy. Hemorrhagic strokes may require surgical intervention for evacuation of clot if the patient meets certain criteria [9].

Management

The head CT is reviewed for the presence of surgically significant intracranial hemorrhage [10]. In addition, there are specific radiographic markers that predict increased ICP. These include effacement of the basal and convexity subarachnoid spaces (so-called "cisternal effacement"), mass effect (compression/deformation of adjacent brain structures), and shifting of the brain contents from one side to the other causing "midline shift." Patients with certain facial, skull base, and cervical fractures are at risk for cervical intracranial vascular injury and dedicated vascular imaging may be indicated. Conventional angiography, CT, and MRI-based angiography are all potential considerations in these situations. Conventional angiography is the gold standard for injury detection and offers the option of endovascular treatment; however, it is also time intensive and may separate the patient from the optimal critical care environment for a protracted period. CT angiography is convenient and rapid, but may miss some injuries. MRI angiography may be more sensitive but has the same downsides as MRI in other trauma settings. No highly regarded predictive tool exists, but risk factors that should prompt consideration of a vascular injury and subsequent vascular imaging include an unexplained neurological deficit, massive facial bleeding, or epistaxis, fracture involving the foraman lacerum of the skull base or foramen transversarium of the cervical vertebrae.

At the conclusion of the of the head CT scan, the clinical and radiographic information should be synthesized to formulate a plan either to operate to evacuate an intracranial lesion, to evaluate for intracranial hypertension with monitoring technology and clinical examination, or to observe clinically for worsening of neurological status with clinical examinations alone. Radiographic assessments, similar to clinical assessments, are often iterative with repeat imaging used regularly to assess for an alteration in status and optimal management plan [10].

Management of NSU patients at risk for aspiration should be aimed at prevention by proper aspiration precautions and positioning along with prophylactic intubation in patients with poor GCS and inability to protect their airways [11]. NSU patients either on mechanical ventilation or on oxygen supplementation must be placed in a semirecumbent position. In mechanically ventilated patients, other strategies to prevent ventilator associated pneumonia such as adequate hand washing between patient contacts, and avoidance of gastric distention are important in order to prevent pulmonary infection. Once aspiration is suspected, aggressive therapy with ventilator support, tracheal suctioning and adequate fluid correction should be instituted. A recent study demonstrated that variations in extubating TBI patients affect the incidence of nosocomial pneumonia since most of them could be related to aspiration. Patients with delayed extubation (> 3 d) developed more pneumonias than patients extubated within 48 h (38 vs 21%, $p < 0.05$). There was a similar reintubation rate in both early and delayed extubation groups. These data suggest that removing endotracheal tubes as soon as clinically feasible may be important in this patient population to prevent pulmonary infection.

Empiric antibiotic coverage is usually recommended for patients with fever, leukocytosis, and positive blood or sputum culture. However, it is crucial to entertain some clinical features of NSU patients before beginning antibiotic therapy. First, older patients usually do not mount a fever or leukocytosis despite an overwhelming infection. The aged with pneumonia after aspiration present with atypical features, including confusion, lethargy and general deterioration of condition. Second, fever is observed in 25% of patients within 48 h after stroke and the most probable cause of fever associated to infection is pneumonia. Third, these patients may also experience other medical complications such as urinary tract infection, sinusitis, intravenous line infection and venous thrombosis. Therefore, it is recommended that a thorough and integral approach be undertaken to investigate each of these conditions [11].

CONCLUSION

Emergencies in neurology, on the one hand due to their high frequency and on the other due to the need for early care and adequate intervention in order to save lives and prevent complications, play a very important role in medical care. Patients are often vitally endangered and a large number of them are in intensive care neurological units where adequate monitoring, assessment of cerebral perfusion, oxygenation and metabolism through a series of specific tests is possible. The clinical picture includes disorders of consciousness, disorders of cranial nerve function, muscle weakness, sensory outbursts, tonic-clonic convulsions and many others.

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ETHICAL STATEMENT

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CONFLICTS OF INTEREST

The author declare that there is no conflict of interest.

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