

Short Communication

Maximal Medical Management: Pushing the Critical Envelope Further

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More recently than neurologists would like to admit, certain diagnoses came with extraordinarily poor prognoses: proximal artery occlusions, aneurysmal subarachnoid hemorrhage, intraparenchymal hemorrhages, intraventricular hemorrhages, to name just a few. Patients with these diagnoses received maximal medical management, but the associated mortality and morbidity was very high despite this management.

Fortunately, over the years, pharmaceutical and technical advances have continually expanded what 'maximal medical management' means, and what it can achieve. In the 1950s, with the more widespread use of ventilators in anesthesia and intensive care units (ICUs), physicians could keep patients alive past the point where neurological decline caused respiratory collapse. Maximal medical management could prolong life, and for patients with neurological emergencies, maximal medical management gave rise to a new field of neurology: Neurocritical care.

In the 1980s, the field of Neurocritical care was born [1]. Academic institutions began to rely on the expertise of neuro Intensivist to provide maximal medical management in the setting of acute brain injury and mitigate complications such as acute respiratory failure, hematoma expansion, central fever, cerebral salt wasting, and intracranial hypertension. The goal was, ultimately, to improve patient outcomes [2,3].

Fast-forward another decade or so to the mid-1990s and the administration of tPA in ischemic stroke was first reported in the *New England Journal of Medicine* [4]. Now, we routinely give intravenous tPA for ischemic strokes, and 'door-to-needle' times are of utmost importance in comprehensive stroke center certification. We have normothermia, hyperglycemia and dysphagia bundles to improve outcomes [5]. Maximal medical management has continued to evolve, and many trials-including stroke trials [6,7]-compare potentially invasive interventions against the ever-changing standard of 'maximal medical management'.

Over the years, some surgical therapies have shown clear benefit over medical management. For instance, now we have the possibility of embolectomy for proximal artery occlusions [8], the use of coiling or clipping to secure aneurysms [9,10], and open and minimally invasive surgical techniques for clot evacuation [11]. In other diagnoses, there is equipoise between medical and surgical intervention. However, in some conditions such as cerebral edema, the treatment remains primarily conservative. From a Neurocritical care perspective, there is much to be done to mitigate the intracranial hypertension related to cerebral edema from various etiologies, including stroke: for example, reduction in cerebral blood flow with anesthetics, increased venous drainage, hyperosmolar and hypertonic medications, and normo- or hypothermia [12].

At our institution, we have taken maximal medical management of cytotoxic and vasogenic edema one step further and implemented a hospital-wide "Brain Code" system. This system was adopted in 2012, and is modeled after the now-familiar but once-revolutionary "Stroke Code" [13]. When clinical, neuro monitoring, or radiographic signs of intracranial hypertension or herniation are apparent, a healthcare provider pages a "Brain Code" through the operator, which brings the pharmacist, Neurocritical care physician, and "Brain Code" box to the bedside. Within the first two years of implementation, more than 75 brain codes were called at our institution. The average time to administration of potentially life-saving medication has improved from greater than 40 minutes to 11 minutes in the era of the Brain Code-a highly significant improvement both in terms of statistics and the quality of patient care. When it comes to the brain, time matters [14]. We need to be able to give these medications in the most time-sensitive manner possible, and we are using the 'code' model to push the envelope and achieve faster administration.

This system was suggested by the Emergency Neurological Life Support course [12] and called for by neurological academicians [15, 16], but we are one of the first academic medical centers to have implemented a formalized brain code process. Using the Brain Code system, we can more effectively manage intracranial crises. We hope other institutions will implement a similar system; without it, medical management of neurological emergencies simply are not maximized.

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