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Advancing the Multidisciplinary Approach to Spinal Cord Injury Risk Reduction in Thoracoabdominal Aortic Aneurysm Repair

SINCE the publication by Betty Grundy[1] in this journal in 1983 about the intraoperative monitoring of sensory evoked potentials, this technique has become a valuable research and intraoperative tool. In this issue of ANESTHESIOLOGY, Timothy Shine *et al.*[2] present the results of a retrospective study evaluating the application of motor and sensory evoked responses during surgery on the thoracoabdominal aorta using regional lumbar epidural cooling. This highlights the changing role of electrophysiologic monitoring during surgery and the multidisciplinary approach to provide the optimal outcome in surgeries where the nervous system is at risk.

Numerous articles have been published demonstrating the utility and efficacy of electrophysiologic monitoring, and a cadre of multispecialty individuals have developed a new field of intraoperative neurophysiologic monitoring replete with training programs, certification processes, and national and international societies. In the meantime, scores of surgeons gained insight into the impact of their surgical maneuvers by observing the monitoring and changing their operative strategy. As such, many surgeons today actively request monitoring to assist them in procedures where monitoring has become as common as other surgical tools, such as the operating microscope or intraoperative fluoroscopy. In essence, the monitoring allows them to get almost instantaneous information regarding the impact of their procedures on the nervous system in a way that is more consistent with function than with structure. In general, the monitoring is used to improve neural outcome, but its presence could also influence nonneural morbidity (positively or negatively). With the US Food and Drug Administration approval of transcranial motor evoked potentials in 2002, this has become the most commonly used tool standard during surgery on the spine and aorta, where the risk of paralysis is one of the most feared complications.[3]

Surgery on the thoracoabdominal aorta is an excellent case study in the growth and application of monitoring. Paralysis occurs in 10–30% in this surgical context, and nonneural morbidity and mortality are significant. Monitoring has played a major role in the reduction of the risk of paralysis by guiding intraoperative management strategies. During the aortic cross clamp, the entire blood supply to the spinal cord is supplied through the vertebral arteries. Somatosensory evoked responses played a role in demonstrating that the presence of a proximal-to-distal bypass perfusion was often necessary because of the often noncontiguous nature of the anterior and posterior spinal arteries.[4] Further, it was noticed that some patients required higher than expected perfusion pressures (as high as 90–110 mmHg). When these strategies are used, the risk of paralysis was reduced to approximately 10% from the greater than 30% risk with cross clamping alone.[4]

Reducing the risk further is dependent on identifying radicular perforators that are critical to the spinal cord blood supply between the cephalad and caudal supply. Best known is the arteria radicularis magna (also know as the artery of Adamkiewicz). As the major blood supply to the lumbar spinal cord, its origin is usually in the T9–T12 aortic segment, and its reimplantation reduces the risk of paralysis to 5–6%. However, other radicular perforators may also be critical in some patients (especially in the T4–T7 region).[4] Monitoring (especially motor evoked potentials) has been used to identify these vessels, and reimplantation reduces the risk of paralysis even further (to below 5%).[4] However, extending the cross clamp time to do this may increase the nonneural morbidity.

In essence, the surgeon works within a time conundrum. The shorter overall cross clamp time reduces the global ischemic time of the spinal cord, reducing the chance of ischemic injury and reducing other nonneural morbidities.[5] However, the extra time spent in identifying and reimplanting critical radicular arteries may reduce neural injury, but may increase nonneural morbidity such that the trade-off is not immediately obvious.[5–7] Strategies to extend the safe operative time might change this risk-to-benefit relationship.

Evolving in parallel to strategies based on monitoring have been other techniques to reduce neural morbidity as well as reducing operative mortality and damage to other organs (especially the kidneys and mesentery). These include cerebrospinal fluid drainage and regional (epidural) spinal cord cooling.[8,9] Cooling extends the allowable period of organ ischemia while avoiding some of the risks of total body hypothermia. One surgeon suggests that combining these surgical strategies with

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the electrophysiologic monitoring strategies may be necessary to allow maximal reduction in the neural injury that most patients fear.[8,9]

The current publication represents a retrospective study of the combined approach using regional epidural cooling and evoked potential monitoring. In addition to reducing the risk to the neural system, the cooling should allow an extension of the time available to identify and reimplant the critical vessels. However, it was not clear whether spinal cord cooling would impact the ability of the neuromonitoring to be sensitive to spinal cord ischemia. What was also not clear is the impact of these strategies on the mortality rate of these patients, the impact on other major morbidities (such as renal failure), and the incidence of neural injury that occurs in the postoperative period.[8]

The authors give us a preliminary answer to some of these questions when they reviewed the records of 60 patients who underwent thoracoabdominal aortic aneurysm repair with left atrial–to–left iliac bypass, regional epidural cooling, cerebrospinal fluid drainage and reimplantation of radicular vessels (where possible) with monitoring of somatosensory evoked responses, motor evoked potentials, and H reflex. Of the 60 patients, 58 had satisfactory baseline responses for evaluation, but not all had responses after epidural cooling. When responses were present with cooling, the shorter median time to loss and the longer duration of loss with cord clamping was related to the risk of spinal cord injury. All patients with spinal cord injury had persistent loss of motor evoked potentials after cross clamp release, although some patients who did not sustain spinal cord injury had persistent loss. H reflex followed motor evoked potentials changes, but the somatosensory evoked responses did not.

What is exciting is that the monitoring was able to be used successfully and it had a high negative predictive value (96%), suggesting that when the motor evoked potentials were lost with cross clamping, efforts to ensure the optimal spinal cord perfusion should be used. As the authors point out, the validation of the risk reduction and changes in nonneural morbidity and mortality will require a multicenter trial because the total numbers in this review are small. As a preliminary finding, this is exciting and may move us closer to providing optimal operative care for these patients.

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