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Preventing Complications during Aneurysm Clipping – the Role of Neuromonitoring.

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The Case

A 73-year-old?female patient was transferred from an outside hospital to a tertiary center with subarachnoid hemorrhage due to a ruptured aneurysm.? At approximately 1000 on the date of transfer, the patient was scheduled for right frontotemporal craniotomy and aneurysm clipping with neuromonitoring to start at 1930.? Neuromonitoring was included on the booking slip, and the neurosurgery resident called the Operating Room (OR) front desk to confirm.? The attending neurosurgeon was not present for the?huddle but?arrived for positioning of the patient and realized that the neuromonitoring technician was not present.? The OR front desk stated that neuromonitoring had not been called, but the attending surgeon decided to proceed with the procedure.? No problems were identified during surgery, but the patient emerged from anesthesia with left-sided paralysis, and post-op imaging showed evidence of a new stroke.? Postoperative morbidity and mortality review suggested that this stroke may have been prevented if neuromonitoring had been performed during the surgery.?

The Commentary

By Christi DeLemos, MSN, CNRN, ACN-BC

Subarachnoid hemorrhage is associated with high mortality and a risk of lifelong disability.[1] Ruptured cerebral aneurysm is the most common cause of subarachnoid hemorrhage accounting for 75% of all subarachnoid hemorrhage cases.[2] The risk of rupture is dependent on two variables, size and location. The International Study of Unruptured Intracranial Aneurysms followed 4060 patients with unruptured intracranial aneurysms. The authors found that the largest aneurysms located in the posterior circulation had the greatest risk of rupture, compared with smaller aneurysms and those in the anterior circulation.[3] Because non-ruptured brain aneurysms produce no symptoms, the most common presenting symptom is “the worst headache of your life”, the hallmark symptom of rupture.[4] The headache is often accompanied

by other signs of meningeal irritation including nuchal rigidity, nausea, vomiting and photophobia. Up to 40% of patients experience a sentinel bleed, characterized by a warning headache that precedes the major rupture of the aneurysm.[5] Because the brain is enclosed within the rigid skull, large-volume hemorrhages produce more severe symptoms including coma and death.

Once an aneurysm has ruptured, it produces a cascade of dysfunction in the sympathetic and parasympathetic nervous system. This process leads to arrythmias including ST and T wave changes, neurogenic pulmonary edema, hypertension, hyperglycemia and delayed cerebral ischemia.[6,7,8,9,10] Management of these symptoms create practical challenges. Early treatment efforts focus on securing the aneurysm with clipping or endovascular intervention, which offers the benefit of preventing rebleeding and its devastating neurological outcomes. Kienzler et al evaluated outcome after in-hospital re-bleeding in 243 consecutive patients with aneurysmal subarachnoid hemorrhage. Eleven percent of patients suffered rebleeding of the aneurysm. Rebleeding was fatal in 71% of patients and caused severe neurological outcome in the survivors.[11,12]

Aneurysmal rebleeding occurs more frequently within the first 6 hours after the initial subarachnoid hemorrhage. Risk factors associated with rebleeding include high systolic pressure, the presence of an intracerebral or intraventricular hematoma, poor (III-IV) Hunt-Hess grade (symptom-based scoring severity classification for subarachnoid hemorrhage), aneurysms in the posterior circulation, and an aneurysm >10 mm in size.[13] For these reasons, the timing of treatment to secure the aneurysm is crucial. Intraoperative somatosensory-evoked potential (SSEP) and motor-evoked potential (MEP) monitoring are often used to detect cerebral injury as a result of clipping. The clipping of cerebral aneurysms is technically difficult with a risk of unintentional injury to branch vessels. Despite advances in microsurgical technique, vessel branches that are not visible to the surgeon can inadvertently be included the clip, producing ischemia and stroke. New post-operative stroke occurs in up to 11% of patients undergoing aneurysm clipping.[14] To mitigate this risk, neurosurgeons began using neuromonitoring in the mid 1980's. A review of 35 studies involving 4011 patients concluded that combined somatosensory evoked potential (SSEP) monitoring and motor evoked potential (MEP) monitoring provided the best diagnostic test accuracy to detect cerebral injury during clipping of cerebral aneurysms.[15] Neuromonitoring is often reserved for complex cases and has been shown to have high negative predictive value (95%) and high specificity (89.9%) but has a sensitivity of 45%.[16] Multimodal monitoring that includes intraoperative neuromonitoring is not mandatory but may lower the risk of post-operative morbidity and mortality.[17]

Approach to Improving Safety

Cerebral aneurysms typically occur at the bifurcation of major vessels or within the Circle of Willis. Critical to successful surgical treatment is the surgeon's identification of vessels that emerge from the dome of the aneurysm or perforator vessels that can become trapped in the surgical clip. Pritz examined the incidence of perforator vessels that could become caught in the aneurysm clip. In a series of 142 cases, they found perforators were present in 7% of basilar artery bifurcations, 17% of internal carotid artery bifurcation aneurysms, 12% of middle cerebral artery aneurysms, and 11% of anterior communicating artery aneurysms.[18]

Neuromonitoring during aneurysm clipping has been shown to reduce the risk of injury to perforating arteries by allowing for real time detection of ischemia before the injury becomes permanent. A range of other intraoperative techniques including doppler ultrasound, intraoperative indocyanine green angiography (ICGREEN) and neuroendoscopy have also been employed to detect imperfect aneurysm clipping and immediately readjust the clip. These techniques significantly reduce the risk of operative complications.[17]

Key to minimizing the risk of inadequate operative monitoring is a pre-operative workflow that identifies all of the needed personnel and equipment. This workflow ensures that critical elements essential for the case are not missed. Case volume at most hospitals is insufficient to support full-time (24/7) coverage by certified surgical neurophysiologists. This service is often staffed by on-call consultants who require lead time for scheduling, which impacts care for patients who require emergent surgical intervention. Communication between off-site neuromonitoring consultants and the OR team should include clear instructions on how to access services and agreed-upon response times. In this Case, appropriate orders were placed for neuromonitoring and the surgical team was faced with balancing the risk of re-rupture versus the benefit of possibly detecting an ischemic complication. Direct communication between the attending surgeon and the operating room staff may have informed the surgeon of the lack of neuromonitoring earlier, potentially correcting the failure to arrange neuromonitoring in a timely manner.

Reliance on resident staff members and indirect channels of communication can be problematic. Vigilance and follow up are required to ensure that resident learners are supported, and closed loop communication is verified. Huddle procedures are an effective tool to promote safety and clear communication before operative care. The Joint Commission has reinforced the importance of the universal protocol to address missing information or discrepancies in the plan prior to starting the procedure.[19] Presence of the surgeon during this process is essential. A shortcoming in the above case is the failure to assure that key team members were present for the procedural pause. If the surgeon had been present, it might have led to a decision to delay the procedure until neuromonitoring personnel were available.

Take Home Points

- The urgency of emergent surgical conditions influences medical decision making and care should be taken to confirm essential staff, equipment and patient safety.
- Procedural pause should always involve the primary surgeon.
- Resident learners should be supported with supervision to ensure closed loop communication and safe care.
- Risk-benefit in emergent surgical care should be carefully weighed to avoid preventable complications and optimize functional outcome.

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