Spinal Cord Ischemia Management: Current Indications and Timing for Drainage

Current indications for drainage, prophylactic versus selective drain protocols, and ideal timing if drainage is indicated.

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Spinal cord ischemia (SCI) is a potentially devastating complication associated with thoracoabdominal aortic aneurysm (TAAA) repair and remains relevant in the endovascular era. Recent studies have demonstrated mortality between 10% and 20%, although up to 60% can remain wheelchair-bound, resulting in higher long-term mortality.[1-4] Poor prognostic factors for recovery include severity of initial insult, lack of improvement in the first 24 hours of symptoms, advanced age, and female sex.[2,4] Although endovascular approaches mitigate many of the hemodynamic stresses related to open repair, the risk of SCI persists with both open and endovascular approaches and increases with the extent of aortic coverage. SCI rates for Crawford extent II TAAA repair range from 2% to 22% and non-extent II rates (extent I, III, IV) are much lower, ranging from 2.6% to 8%.[5-8] This pathology remains particularly relevant given recent advances and successes in complex endovascular repair of thoracoabdominal aortic disease.

CAUSES AND RISK MITIGATION STRATEGIES

The main drivers of acute SCI are malperfusion resulting from disruption of blood flow to the anterior spinal artery, intercostal arteries, and other collateral networks (eg, vertebral artery, hypogastric artery). Blood flow to the spinal cord is also modulated by perfusion pressure—the difference between mean arterial pressure (MAP) and intraspinal canal pressure—and therefore systemic hypotension or increased intraspinal canal pressure can jeopardize perfusion to the cord. Distal embolization during interventions also serves as an important etiology.[9]

Numerous preoperative techniques have been developed to mitigate the risk of SCI with the main goal of maintaining adequate spinal cord perfusion pressure and adequate collateral pathways, with specifics depending on the particular intervention. For example, patients undergoing thoracic endovascular aortic repair (TEVAR) who require coverage of their left subclavian artery (LSA) often undergo pre-TEVAR left carotid-subclavian bypass or transposition to ensure left vertebral artery patency. Certain patients may benefit more from this, including those with a dominant left vertebral artery or those with a prior EVAR. Some groups advocate for staged procedures beginning with TEVAR to allow for collateralization over time.[10,11] Minimally invasive segmental artery coil embolization is another prophylactic technique that some groups have utilized.[12-14] This procedure is based on the collateral network concept of spinal cord perfusion, which suggests that intentional endovascular segmental artery occlusion of intercostal branches can mobilize nearby spinal arterial networks in anticipation of future aortic coverage approximately 2 to 8 weeks later, helping to prevent SCI.

In general, the approaches to mitigate the risk of SCI include avoidance of hypotension, maintenance of optimal oxygen delivery, as well as the selective addition

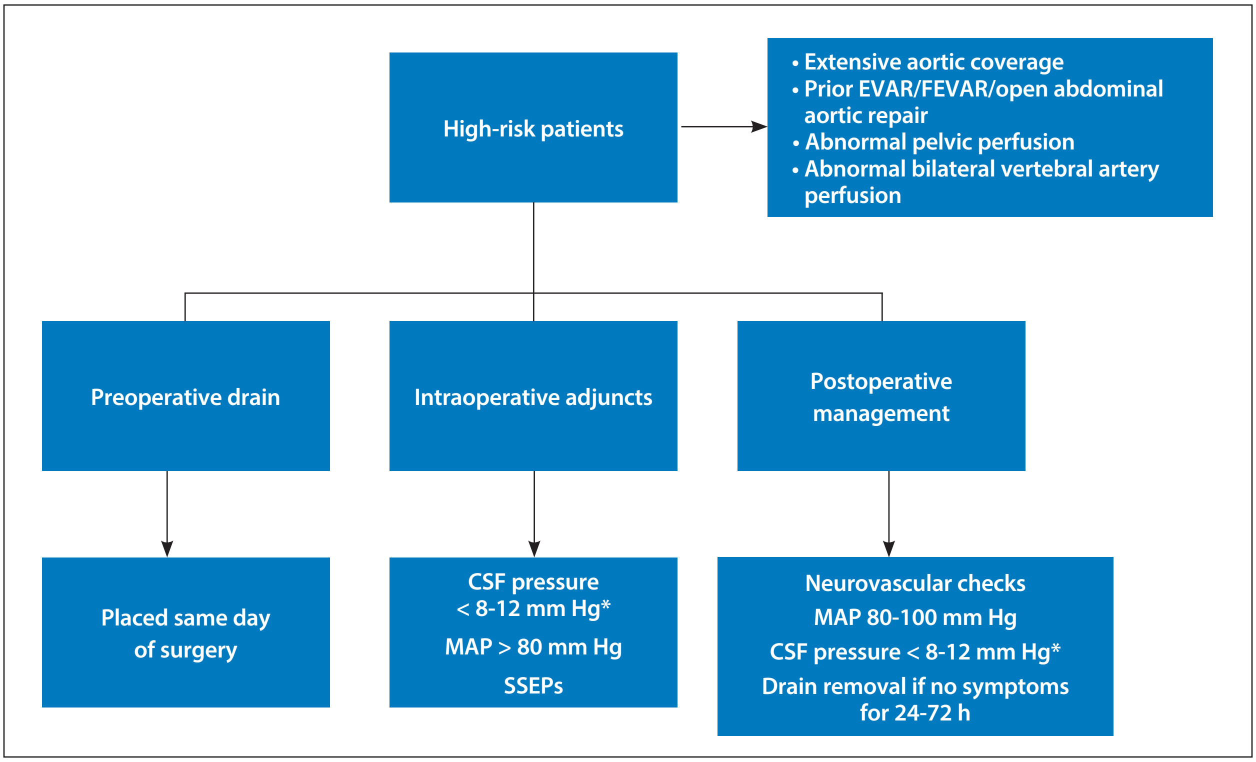

Figure 1. Our institutional protocol for spinal drain placement for high-risk patients. EVAR, endovascular aneurysm repair; FEVAR, fenestrated endovascular aneurysm repair. *Drain no more than 15-20 mL/hr.

of invasive adjuncts such as the use of a lumbar spinal drain.[15,16] If there is concern for SCI, drainage of cerebrospinal fluid (CSF) can be initiated to reduce pressure in the subarachnoid space (usually to 8-12 mm Hg) and increase spinal cord perfusion pressure while concomitantly raising MAP with vasopressors. Numerous tools can be used to monitor intraoperative spinal cord perfusion, including somatosensory evoked potentials (SSEPs), motor evoked potentials, and less invasive techniques such as near-infrared spectroscopy.[17,18]

INDICATIONS FOR DRAINAGE

The use of prophylactic spinal drainage is commonly used in patients at high risk for perioperative SCI, including extensive aortic coverage (extent II/III repairs), history of prior open or endovascular aortic repair, bilateral vertebral artery disease, occlusion of hypogastric arteries, advanced age, patients presenting nonelectively, atrial fibrillation, and renal insufficiency.[19,20] The potential complications associated with drain placement are not uncommon and can be significant, including spinal hematoma leading to paralysis, intracranial hemorrhage, and meningitis.[21,22] Other less severe complications can also occur and include catheter fractures, local skin infections, mechanical fractures, and CSF leaks.[23,24] Studies have quoted that significant complications occur between 1 and 20 and 1 in 50 patients.[25] In addition, the rate of nonfunctioning drains is not insignificant, occurring in up to 20% of patients.[21]

Although many groups initially advocated for prophylactic drainage in all TEVARs, the paradigm seems to be shifting to selective and rescue placement. Most of the early impetus to support routine use of CSF drainage arose from the 2010 American College of Cardiology Foundation and American Heart Association guidelines.[26] However, these guidelines were based mainly on three studies of open thoracic aortic surgeries and not on TEVAR or branched endovascular outcomes.[27-29] Unfortunately, there has been no level I evidence to support routine CSF drainage with TEVAR or branched/fenestrated repairs or trials comparing the use of prophylactic spinal drains to "rescue drain" for patients who develop perioperative or delayed symptoms. Many groups now advocate for selective and rescue use of spinal drains, and these decisions are based on retrospective studies and large review studies, although many of the practice patterns developed vary greatly among institutions with regard to indications, timing, drain settings, drain duration, and blood pressure management.[30-33] Differences in institutional

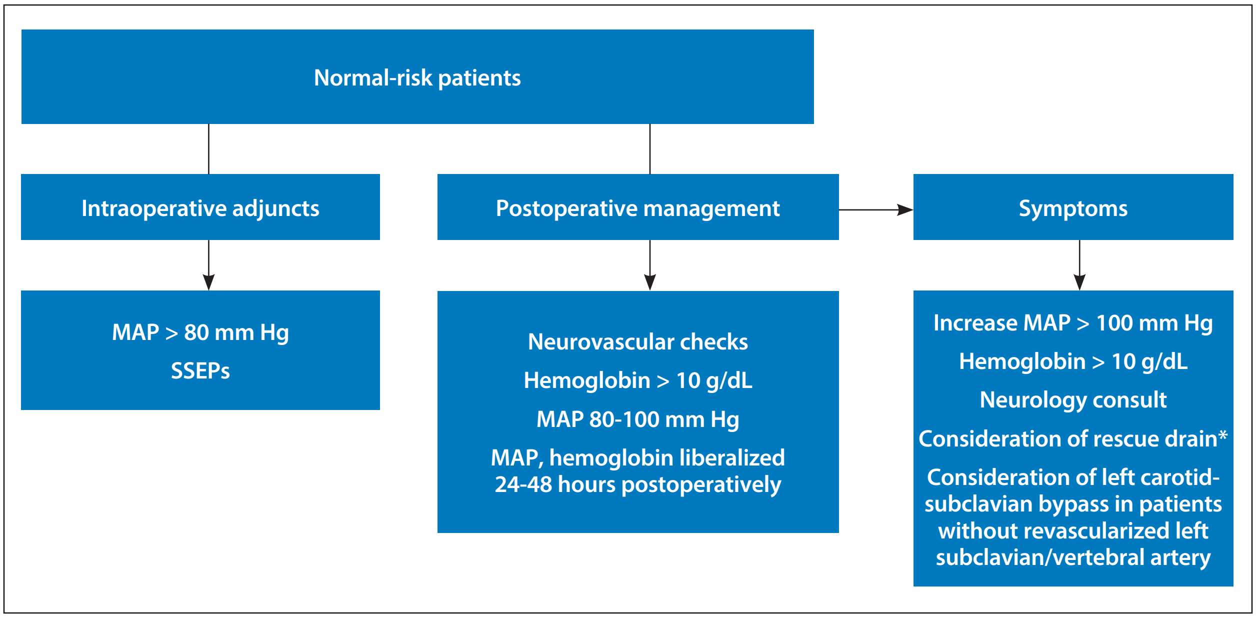

Figure 2. Our institutional protocol for spinal drain placement for normal-risk patients. *Drain no more than 15-20 mL/hr.

resources, including the ability to provide rescue drain placement by experienced anesthesia staff at all hours and as specialized nursing to detect early signs of SCI, influence practice patterns with regard to prophylactic versus selective lumbar drain placement.

Our own institutional practice is to employ selective placement of spinal drains for high-risk patients (Figure 1). For normal-risk patients, we do not place prophylactic spinal drains and provide rescue drains in the appropriate clinical setting (Figure 2). If a patient requires coverage of their LSA, a preoperative left carotid-subclavian bypass or left subclavian transposition is performed. Most commonly, high-risk patients include those with coverage of the entire thoracic aorta and prior history of EVAR or open abdominal aortic aneurysm repair. Intraoperatively, SSEPs are used for continuous neurologic monitoring and a MAP goal is maintained at > 80 mm Hg after device deployment. Patients then spend 24 to 72 hours in our cardiovascular intensive care unit, where they undergo serial neurovascular checks and strict blood pressure control.

If symptoms of SCI present, patients quickly enter a permissive hypertension protocol to raise MAP > 100 mm Hg and undergo neurology consultation and evaluation for spinal drainage. The decision to place a drain should move forward rapidly if symptoms do not improve quickly with blood pressure augmentation, as some data suggest that even minor delays can result in worse outcomes.[34] Drains usually remain in place for 24 to 72 hours after symptoms plateau with increasing drainage rate up to 15 to 20 mL/hr depending on symptom severity and improvement. The drains are monitored for bloody or pink drainage with a hemoglobin goal > 10 mg/dL. Patients remain flat while the drain is in place. If SCI symptoms do not resolve with measure to increase MAP and lumbar drain placement and the LSA has been covered due to the emergent nature of their TEVAR, urgent left carotid-subclavian bypass should be considered.

SUMMARY

Methods to prevent SCI are a topic of continued debate, and most practices are based on expert opinion and experience rather than level I evidence. The ability to adhere to a selective or rescue drain placement protocol also relies on the availability of staffing 24/7 or anesthesia or other services capable of placing a drain. Currently, there is a rapidly evolving outlook with regard to prophylactic spinal drain placement in endovascular treatment of TAAAs, with an increasing number of physicians shifting to selective and rescue drain protocol. Clinical trials with fixed protocol patterns are needed to further delineate spinal drainage best practices moving forward. ■

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