Pro: Patients at Risk for Spinal Cord Ischemia After Thoracic Endovascular Aortic Repairs Should Receive Prophylactic Cerebrospinal Fluid Drainage

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Thoracic endovascular aortic repair (TEVAR) has become established as a less invasive option for the management of descending thoracic aortic diseases compared with conventional open surgical repair. TEVAR has reduced morbidity and mortality compared with open surgical repair, but still it is associated with a significant risk of spinal cord ischemia (SCI), which can lead to permanent paraplegia.[1] The 2 major recognized medical interventions to prevent and treat spinal cord ischemia in patients undergoing TEVAR are arterial pressure augmentation and lumbar cerebrospinal fluid (CSF) drainage.[2] Despite limited evidence from randomized controlled trials,[3] the published clinical experience supports the effectiveness of CSF drainage as an adjunct for the treatment of patients with SCI and in prevention of permanent paraplegia as a consequence of TEVAR.[2,4–7] Although there is little controversy regarding the use of lumbar CSF drainage for the treatment of SCI, considerable controversy exists as to whether preoperative insertion of a lumbar CSF drain is warranted as a prophylactic measure in patients undergoing TEVAR. Based on the existing clinical experience published in the medical literature, an argument can be made to support the routine use of prophylactic CSF drainage among patients undergoing TEVAR who are deemed preoperatively to be at high risk for SCI.

The reported incidence of SCI after TEVAR ranges between 0% and 10.3%, with the average incidence being between 3% and 5%.[8] Published clinical series suggested that the risk of SCI associated with TEVAR was less than that associated with open surgical repair;[9] however, there was significant anatomic heterogeneity in these series. Indeed, most TEVAR procedures were performed for aortic pathology limited to the descending thoracic aorta. When patients with thoracoabdominal aortic aneurysms were included and the extent of aortic coverage or replacement was comparable, the actual risk of SCI was similar between TEVAR and open repair. The pathophysiologic basis for SCI after TEVAR relates primarily to endovascular coverage of intercostal and segmental collateral vessels within the excluded aneurysm, thereby compromising the net collateral vascular supply to the anterior spinal artery.[9,10] TEVAR for more proximal thoracic aortic pathologies requiring coverage of the left subclavian artery similarly may compromise vascular collaterals from the vertebral artery that supply the anterior spinal artery. Prior distal aortic surgery, preexisting peripheral arterial disease, or vascular access site-related complications also may compromise vascular collaterals from the pelvic, lumbar, or hypogastric vessels that supply the spinal cord. Compromise of more than one vascular collateral supply to the spinal cord, often in combination with systemic hypotension, will produce the conditions that predispose patients to SCI (Fig 1).

The American College of Cardiology Foundation and American Heart Association (ACCF/AHA) guidelines on the management of thoracic aortic diseases[11] assigned a class I recommendation for CSF drainage as a spinal cord protective strategy for open and endovascular thoracic aortic repair. A class I recommendation means that it was the consensus opinion of experts in the field that the benefits of the procedure far exceeded its risks and that the procedure should be performed. However, the recommendation was qualified by the statement that CSF drainage should be used only for patients at high risk for SCI injury. For this reason, it is important to assess the risk of SCI in patients undergoing TEVAR when making the decision to use prophylactic lumbar CSF drainage. Risk factors that predict a higher risk of SCI in patients undergoing TEVAR have been well characterized in published clinical experiences (Table 1). Longer aortic stent grafts or the use of multiple stent grafts covering a greater extent of the thoracic aorta (>30 cm) require the obligatory sacrifice of a greater number of intercostal and segmental arteries that contribute to spinal cord perfusion.[12,13] Patients with prior abdominal aortic aneurysm (AAA) repair were at an increased risk of SCI due to compromised lumbar, pelvic, hypogastric, and inferior mesenteric artery collaterals.[14] In a series of 72 patients who underwent TEVAR after prior AAA repair, the risk of SCI was 12.5%, compared with the 1.7% risk of SCI in patients without prior AAA repair (relative risk, 7.2; 95% confidence interval [CI], 2.6-19.6; $p < 0.0001$).[15] Similarly, patients undergoing TEVAR who required coverage of the left subclavian artery had a higher risk of SCI as a

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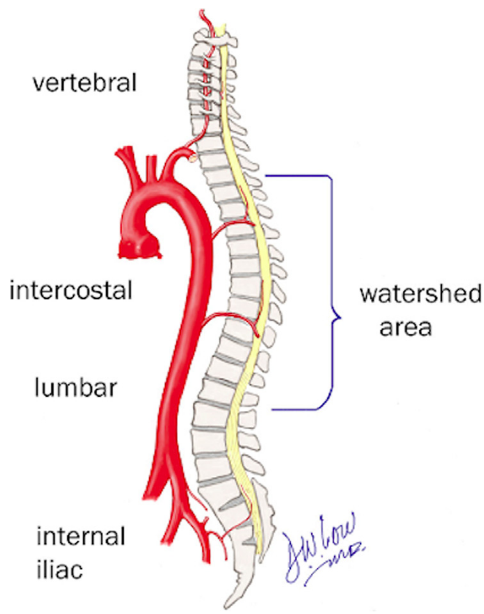

Fig 1. Branch vessels from the thoracoabdominal aorta form the collateral vascular network supplying the spinal cord. The vertebral arteries that branch off the subclavian arteries, together with the cervical vascular network, supply the upper portion of the collateral network in the region of the cervical and upper thoracic spinal cord. The thoracic intercostal and lumbar segmental arteries that may include a prominent midthoracic radicular artery together with the arteria magna radicularis (artery of Adamkiewicz) supply the mid portion of the collateral network in the region of the thoracic and lumbar spinal cord. The hypogastric vascular network, which forms from branches of the lumbar segmental arteries, middle sacral artery, lateral sacral arteries, and iliolumbar arteries, supplies the lower end of the collateral network in the region of the conus medullaris. Endovascular coverage or sacrifice of intercostal arteries, segmental arteries, and arteries supplying the hypogastric vascular network may cause a watershed infarction of the spinal cord in the region of T4 to the conus medullaris. (From Ullery and Wang, 2011)

consequence of compromised collateral supply from the vertebral artery.[16] Advanced atherosclerosis and chronic renal insufficiency also have been linked to increased risk of SCI, likely related to the burden and severity of peripheral arterial disease.[17] Other risk factors that have been associated with SCI include advanced age, perioperative hypotension, and emergency surgery. Patients with these risk factors have a greater risk for SCI after TEVAR, therefore justifying the use of prophylactic lumbar CSF drainage.

Spinal cord ischemia can occur during surgery or may be delayed, manifesting in the postoperative period.[4,18] Intraoperative or immediate-onset SCI while the patient was under general anesthesia was associated with a poor prognosis; because the initial onset of ischemia could not be determined, the efficacy of therapeutic interventions could not be assessed by neurologic examination, and spinal cord infarction already had occurred by the time the patient manifested signs of paraplegia. In contrast, delayed-onset SCI, when detected and treated promptly, had a relatively good prognosis.[2,4,18,19] Evidence supports the effectiveness of CSF drainage when combined with arterial blood pressure augmentation for the treatment of patients who develop delayed-onset paraplegia. In published reports, early detection and treatment of SCI resulted in complete or partial recovery of neurologic function after either open surgical repair[20,21] or TEVAR.[22–26] The best reported outcomes were associated with immediate intervention that included lumbar CSF drainage upon the first detection of symptoms. In a case series in which lumbar CSF drains were placed selectively only if SCI occurred after TEVAR, the likelihood of complete or partial recovery in response to treatment depended on how soon the lumbar drain was inserted after the onset of ischemia.[19] All patients who had a lumbar drain inserted >10 hours after onset of SCI had no recovery and went on to develop permanent paraplegia.[19] The existing clinical experience, combined with physiologic rationale, provide strong arguments for the prophylactic insertion of a lumbar CSF drain in patients at risk for immediate or delayed-onset paraplegia. The drain enables treatment to be instituted immediately upon the first signs of spinal cord ischemia to provide the greatest chance for recovery.

The clinical evidence supporting the benefits of lumbar CSF drainage for the prevention and treatment of SCI can be estimated as moderate-to-high, with a low likelihood that additional new information would change the estimation of the benefit. To date, there have been 3 randomized controlled trials (RCTs) examining the use of lumbar CSF drains to prevent SCI in open thoracoabdominal aortic aneurysm (TAAA) repair.[27–29] In the largest RCT, including 145 patients with Crawford Extent I or II TAAA, there was an 80% reduction in the incidence of postoperative neurologic injury from SCI (13% *v* 2.6%, $p = 0.03$) in the group randomized to receive lumbar CSF drainage.[29] In a meta-analysis performed by Cina et al, data from 372 publications involving more than 794 patients, which included 3 RCTs and 5 cohort studies to evaluate the effectiveness of lumbar CSF drainage in patients undergoing open TAAA repairs, found a significant decrease in the incidence of postoperative paraplegia when CSF drainage was used, with a pooled odds ratio of 0.3 (95% CI, 0.17-0.54).[30] A more conservative meta-analysis performed by the Cochrane group also found a significant benefit associated with lumbar CSF drainage when all 3 RCTs were included (odds ratio, 0.48; 95% CI, 0.25-0.92).[3] However, the benefit of lumbar CSF drainage was not quite significant (odds ratio, 0.57; 95% CI, 0.28-1.17) if 1 of the RCTs was excluded because the treatment arm consisted of CSF drainage in combination with intrathecal papaverine.[3] Furthermore, early experimental studies also supported the efficacy of lumbar CSF drainage to prevent paraplegia in animals subjected to aortic cross-clamping and SCI.[31,32]

Although there are no RCTs to validate the benefits of lumbar CSF drainage in patients undergoing TEVAR procedures specifically, the existing published studies examining the utility of lumbar CSF drainage in this patient population were consistent with the findings in patients undergoing open surgical repair.[4–6] The largest prospective observational trial by Hnath et al, in which 121 patients underwent elective or emergent TEVAR, observed no postoperative neurologic deficits in patients who had CSF drainage placed prophylactically; whereas 5 (8%) patients without prophylactic CSF drains went on to develop neurologic deficits within the first 24 hours after TEVAR ($p = 0.05$).[6] The benefit was observed in the group that