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Commentary: The aggregation of marginal gains for spinal cord protection

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CENTRAL MESSAGE

Spinal cord injury is a devastating complication of thoracoabdominal aortic aneurysm repair. The use of cerebrospinal fluid drains is an important adjunct for reducing the risk of spinal cord injury.

In the seminal report of E. Stanley Crawford's experience with 1509 patients with thoracoabdominal aortic aneurysm (TAAA) who underwent surgery from 1960 to 1991, the incidence of spinal cord injury (SCI) with paraplegia was 16% for all TAAA repairs and 31% for extent II TAAA repairs.[1] Yet Crawford and colleagues persisted. After almost 4 decades and many advances in spinal cord protection, including left heart bypass, mild hypothermia, cerebrospinal fluid drainage (CSFD), and reimplantation of intercostal or lumbar arteries, the modern rate of permanent SCI now approaches 5% for TAAA repairs as a whole and 8% for extent II cases.[2]

Abdelbaky and colleagues[3] illustrate the experience of Elefteriades and the Yale group in this issue of *JTCVS Techniques*. This report continues the group's valuable and long-standing contributions to our understanding of the management of thoracic aortic disease. The very good overall results the authors describe attest to the group's experience with this procedure. In this cohort of 100 patients (mean age, 65 years) with descending thoracic aneurysm (DTA; n = 33) and TAAA (n = 67) in which all patients received CSFD, overall mortality was 6%; 4% of patients had transient paraparesis, and 2% had permanent paraplegia. Most cases were elective (92%), with the most common diagnoses being nondissected aneurysm (55%) and chronic type B dissection (28%).

Any meaningful evaluation of a TAAA series and associated SCI complications requires an apples-to-apples comparison. This entails recognizing the distribution of patients with TAAA versus those with DTA and the proportion of the various TAAA extents, with particular attention to extents II and III, which are associated with the greatest risk of SCI.[2] The 67 TAAAs in this series were distributed according to Crawford extent as follows: extent I (26%), extent II (25%), extent III (9%), extent IV (3%), and extent V (4%). Comparing the DTA and TAAA results reflected the significant differences in the risks associated with each. The 30-day mortality rate was 3% in the DTA group compared with 10% in the TAAA group. Similarly, the paraplegia rate was zero in the DTA group and 3% (2/67) in the TAAA group.

To put this in a broader context, in a recent systematic review and meta-analysis by Gaudino and colleagues[4] of 169 studies and 22,634 patients, the overall incidence of SCI was 4.9% for open DTA repairs and 7.0% for open TAAA repairs. The incidence of SCI varied substantially by TAAA extent: extent I (4% incidence of SCI), II (15%), III (7%), IV (2%), and V (7%). A more nuanced comparison would further take into account the mean age of the patients, the proportion presenting with rupture or requiring urgent or emergency surgery, and the proportion

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presenting with chronic symptoms, because all of these factors are associated with increasing SCI risk.[5]

It is important to maintain a sense of humility when reporting good results, as the Yale group has demonstrated when it comes to SCI and TAAA repairs. In our own experience, we have had 4 separate periods during which we performed more than 100 consecutive TAAA repairs (102, 113, 117, and 261) without any permanent paraplegia and another 11 similar periods during which we performed more than 50 consecutive repairs without paraplegia (JS Coselli, unpublished data, 2020). Thus, there is real value to either a large, single-center series or the aggregation of results from a meta-analysis. In Gaudino and colleagues' systematic review, it should be noted that 52 (31%) of the studies included more than 100 patients, 8 (5%) studies had more than 500 patients, and 2 (1%) had more than 1000 patients.[4]

The Yale group used a variety of strategies in addition to 100% CSFD, including left atrial–femoral arterial bypass (96% of cases), preserving intercostal arteries (72%), monitoring motor-evoked potentials (67%), and preoperative detection of the anterior spinal artery (67%). Although we do not routinely use motor- or somatosensory-evoked potentials, we acknowledge that other surgical groups do so with good outcomes.

These results reflect surgical expertise and a variety of preoperative and intraoperative adjuncts, highlighting brilliantly the maxim put forth by British cycling coach David Brailsford of "aggregation of marginal gains," whereby meaningful and noticeable process improvement can result from improvements of as little as 1% across several areas. Thus, several different specific measures can add up to a meaningful reduction in SCI.

The role of CSF drainage in TAAA repair was highlighted in a 2012 Cochrane review of 3 randomized trials that included a total of 287 patients, thereby establishing its role in TAAA repair.[6] Although the conclusion was that CSFD demonstrated "limited data" in DTA/TAAA, the largest of these trials (n = 145[7]) showed an 80% relative risk reduction (12.2% incidence of SCI in the control group vs 2.7% in the CSFD group, $P = .03$) in extent I and II TAAA repairs, which led to CSFD recommendations in both the American (Class IB[8]) and European (Class IIA[9]) guidelines.

Abdelbaky and colleagues' report is further enhanced by providing real-world guidance on a variety of specific perioperative management considerations familiar to all for whom CSFD is part of their routine practice.[10] While the primary focus with CSFD is rightly first on preventing SCI complications, the authors also discuss complications associated with CSFD itself—such as a "bloody tap," spinal headaches, and the use of blood patches—and perioperative management, as detailed by other centers with large experiences.[11,12] The authors' 14% rate of CSFD complications (which were mostly minor: 9% blood-tinged CSF, 1% subdural hematoma) compares favorably with the results of 2 distinct metanalyses that showed an 8% to 13% incidence of complications of variable severity.[4,13]

Standardized surgical techniques and diligent perioperative management with CSFD for TAAA repair can lead to very good surgical outcomes, as Abdelbaky and colleagues demonstrate. These lessons should remain in our practice and inspire the next "marginal gain" toward better spinal cord protection.

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