called “indirect paraspinal collateral network monitoring.”¹⁰ Regardless of the positioning of the optodes, available animal studies^{11,12} have shown promising correlations between NIRS data on regional oxygenation and spinal cord perfusion. Further clinical trials are deemed necessary to investigate if NIRS detected spinal oxygen saturation is an accurate modality for spinal cord blood flow.

In most studies, including the current one, the perfusion pressure with ACP is maintained at (or below) 50 mm Hg to prevent any cerebral edema. However, one wonders whether a slightly higher ACP perfusion pressure and flow (closer to 60 mm Hg) or a lower degree of hypothermia (<22°C) would have any impact on the NIRS-detected oxygen saturation of the spinal cord. Until we obtain an accurate modality to monitor spinal cord perfusion in real time (both intraoperatively and postoperatively), extra caution should be taken in total transverse aortic arch replacement when warmer temperatures during hypothermic circulatory arrest are used for long intervals.

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Commentary: No cord left behind

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Until recently, protection from end-organ injury during aortic arch surgery has focused on the brain. The primary means for organ protection was hypothermia, and because the organ most susceptible to ischemia is the brain, there

John Bozinovski, MD, MSc (left), and Asvin M. Ganapathi, MD (right)

CENTRAL MESSAGE

The move to warmer temperatures during aortic arch surgery should not abandon consideration of the risk to the spinal cord.

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was less impetus to look at other organs. With the advent of selective antegrade cerebral perfusion during hypothermic circulatory arrest, arch procedures are being performed at warmer temperatures. The effect of this change on cerebral protection¹ has been examined more frequently than its effects on other organs, such as the spinal cord. The study in this issue of the *Journal* of Kinoshita and colleagues² does not specifically assess the effect of temperature; however, in light of the move toward warmer circulatory arrest, it provides valuable information. The study presumably examines blood flow to the spinal cord at different levels, from which inferences can be made about the importance of technique when performing arch procedures.

By using oximetry probes at the forehead and at the paravertebral T3 and T10 levels, Kinoshita and colleagues² made an extrapolation about blood flow in the course of 18 circulatory arrest procedures. Although the findings were intuitive, the study provides evidence that the further anatomically from the source, the poorer is the flow. Further, during lower body circulatory arrest, Kinoshita and colleagues² demonstrated that oximetry at T3 was not different from baseline and was stable, whereas at T10, oximetry fell precipitously and plateaued near its nadir after about 20 minutes. The assumption that we can make is that somewhere between the 2 levels, flow is sufficiently affected to become a concern.

Spinal cord injury (SCI) during aortic arch surgery is known to occur, but not with significant frequency.^{3,4} Frozen elephant trunk extension of arch intervention has been identified as a risk for SCI,⁴ but only some arch interventions require frozen elephant trunk extension. That lower body ischemic times are usually less than 90 minutes, and that “sufficient” hypothermia is being used likely has much to do with infrequency of SCI. As we get warmer with arch procedures, either we will find that SCI occurs more frequently, or we will more

regularly incorporate distal perfusion techniques. A straightforward technique for distal aortic perfusion during arch surgery is described in a study by Tarola and associates,⁵ in which 62 patients were compared with 44 patients undergoing arch procedures without distal aortic perfusion. Surgery was performed at mean nadir temperatures of 26°C and 25°C, and circulatory arrest times were 41 and 31 minutes, respectively. One patient in each group had SCI develop; both had an acute type A aortic dissection as the indication for the surgery. No patients undergoing arch surgery for isolated aneurysmal disease had SCI occur.

A weakness of the study of Kinoshita and colleagues² is that direct measurement of blood flow to the regions of interest is not possible, but this is a fundamental problem with current technology. Near-infrared spectroscopy can only be assumed to reflect regional blood flow and organ perfusion. Assuming that to be true, the direction to rely more heavily on cooling, or to incorporate distal aortic perfusion, in procedures with potentially prolonged distal ischemia should be heeded.

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