warranted.” A larger randomized, controlled trial with patients at higher risk that incorporates imaging in addition to clinical endpoints is needed to determine the impact of filtration. Such a study is being sponsored by the National Heart, Lungs, and Blood Institute.

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NEUROLOGIC IMPACT OF USING EMBOL-X INTRAAORTIC FILTER Reply to the Editor:

We greatly appreciate the comments of Allen and Horvath and entirely agree with their interpretation of the facts. We reported the safety and feasibility of using the new version of the EMBOL-X intra-aortic filter during transaortic transcatheter aortic valve implantation and during conventional cardiac surgery, and we documented successful capture of embolic material.¹ Although capturing emboli might be anticipated to decrease embolic events, it has been difficult to demonstrate a positive clinical effect. This may be in part because the majority of embolic cerebral events after transcatheter aortic valve implantation or conventional cardiac surgery are silent. We completely agree that a much larger, randomized study with a combination of imaging and clinical end points in patients who undergo either transaortic transcatheter aortic valve implantation or conventional cardiac surgery will be necessary for full evaluation of the potential for benefit or harm with any embolic control device.

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AORTIC SURGERY AND SPINAL COLLATERAL FLOW: A CALL FOR STRUCTURED APPROACHES TO FUNCTIONAL CHARACTERIZATION OF THE INTRASPINAL COLLATERAL SYSTEM To the Editor:

Generating knowledge of spinal collateral physiology spans over decades of scientific efforts. As will be demonstrated, historical and current knowledge of different specialized areas, such as orthopedic surgical, neurosurgical, neuroradiologic, and aortic surgical science, as well as basic research, need to be combined to generate a comprehensive picture of spinal collateral physiology.

Spinal collateral flow has been the subject of surgical large animal studies, which have proved to be the best available option among scientific models for spinal flow research. The mainstay experimental series from the Mount Sinai Hospital in New York¹⁻³ stand out in this series of experimental efforts. After more than 20 years of translational and basic work shedding light on risks of central nervous deficits after thoracic aortic surgery, tendencies of resignation now can be observed. In their recent letter, Takayama and Borger⁴ come to the conclusion that spinal cord protection might be just as “simple” as keeping perfusion pressures high and to react on evident spinal ischemia as monitored and detected by evoked potentials. It is ignored that we are still far away from solid, evidence-based individual preoperative risk prediction of spinal ischemia. Strategies with predictive validity of spinal ischemia based on individual anatomic settings still need to be established.

Lazorthes and Gouaze,^{5,6} Lazorthes and colleagues,⁷ Lazorthes and Manelfe,⁸ Lazorthes and colleagues,^{9,10} Lazorthes and Zadeh,¹¹ and Mehta¹² are to be credited for probably the most important anatomic contributions to our understanding of the spinal collateral system, more specifically the intraspinal backup system. It seems as if their work somewhat faded into the background, which is not understandable especially regarding Lazorthes and colleagues’ highly detailed and extensive investigations in cadavers. Their results have served as an anatomic basis for the numerous large animal studies by Griep and colleagues at the Mount Sinai School of Medicine in New York City. Other early contributions are by Kadyi,^{13,14} Pisco, and Pisco and Remagen.¹⁶ Paradoxically, orthopedic researchers¹⁷⁻¹⁹ studying venous return from the spinal column primarily described an important piece of the intraspinal collateral system—the serial circular epidural

FIGURE 1. Intraspinal arcades: canine, human, and porcine (from *left to right*). The view is the same as shown in [Figures 2-5](#). All are cadaver casts using different plastic or contrast agent dyes. The 2 large parallel structures at the 2 sides of the spinal canal in the *right* image are the 2 major intraspinal veins, casted in the pig but not in the canine and human examples. The *left* and *middle* images are by Crock and colleagues,¹⁸ and the *right* image is by the Mount Sinai Group.²²

arcades ([Figure 1](#))—as we chose to call them, although without transferring this knowledge to aortic surgical problems or spinal flow physiology. Adamkiewicz’s work²⁰ must be mentioned in the same line of research, although the

hypothesis of a spinal blood supply depending mainly on 1 critical arterial input is obsolete.²¹

The spinal collateral network should be divided in a paraspinous compartment and an intraspinal compartment. These

FIGURE 2. The spinal canal seen from the back, after bilateral laminectomy of 3 vertebrae and removal of dorsal processes. The posterior surface of the vertebrae is exposed. The posterior longitudinal ligament is not shown. The large vessels leaving the spinal canal on every segmental level, 2 at the level of each intervertebral disk, are the major intraspinal veins, draining in a valveless venous system directly connected to the major caval venous systems.

FIGURE 3. Overimposed on the image shown in Figure 2 is the intraspinal collateral system consisting of epidural arcades, the circular structures found on the back of each vertebral body, and their feeders from posterior parts of the segmental arteries (red). The feeding arteries are shown in an interrupted fashion because they partially run below the great intraspinal veins. The arcades connect the segmental levels longitudinally and side-to-side. Beginnings of the arteries running to the paraspinal muscle are shown in orange.

2 compartments have different anatomic substrates with respect to collateral pathways and are likely to have different functions.

In the paraspinal compartment, small interconnecting arterioles between neighboring segments within the paraspinal muscles and along the bony spine are present.²² If one considers Nijenhuis and Backes²³ neuroradiologic work and their impressive studies of spinal magnetic resonance vessel imaging and combines their descriptions of segment-connecting corkscrew-shaped paraspinal collaterals with the concepts of arteriogenesis, which have been studied for decades by Deindl and Schaper,²⁴ then arteriogenesis of the paraspinal muscular arterioles is an obvious hypothesis. The paraspinal vessels are prearteriogenic, natively nonconducting arterioles. They need at least 1 week to undergo arteriogenesis and grow and thus become full conductance vessels after ligation of segmental vessels.^{2,22} We can hypothesize that their function is long-term stabilization of a solid spinal perfusion.

In the intraspinal system, a series of arterial circles all along the length of the spine is present. These are not shown in most of the scientific images and drawings currently published, although it is old knowledge that they exist. As mentioned before, Crock¹⁷ published his findings on this anatomic detail in 1960. These structures are found on the back of each and every single vertebral body. They are interconnecting longitudinally, as well as in a latero-lateral fashion. Unlike the paraspinal vessels, these vessels are small arteries, not arterioles, and they are native conducting vessels just like the circle of Willis. Their anatomic arrangement implies fundamental importance for immediate spinal cord flow backup, and it is the least well functionally defined collateral system in the body. The system is shown in works from Griep's laboratory,^{2,22} but one must look closely to understand its repetitive architectural pattern. The complexity of the interconnections is fascinating; however, they are not too complex for one to identify a pattern. This pattern is shown in principle in Figures 2-5, showing single structures overimposed on the respective prior image to

FIGURE 4. Overimposed on the image shown in Figure 3 is the anterior spinal artery (light blue) running longitudinally. It runs in the anterior sulcus of the spinal cord, posterior (on top of) to the intraspinal arcades. Its feeders are the horizontal anterior ARMAs, shown in dark blue. The ARMA origins are part of trifurcations with 2 feeding branches to the arcades, which are always there. Of importance is that the ARMAs are the only interindividually variable parts of the intraspinal collateral system. The red signs indicate possible occlusion of segmental vessels during thoracic aortic surgery.

illustrate the building concept of the intraspinal collateral system.

In addition, the spinal collateral network should be divided into an anatomically conserved part, which includes the intraspinal arcades, and a highly inconsistent or inter-individually highly variable part. The inconsistent, highly variable parts are the anterior radiculomedullary arteries (ARMAs) (Figures 4 and 5). They were identified in casting studies in porcine cadavers in Griep and colleagues’^{21,22} laboratory, and Coselli mentions them in his discussion of Griep and colleagues’²¹ experience at the 67th Annual Meeting of The American Association for Thoracic Surgery.

The finding that the extent of an aortic aneurysm correlates to spinal cord ischemia risk reflects the importance of distance between inflow and the next ARMA. This can be easily seen in the scheme shown in Figures 3-5.

If a patient undergoing ligation of all thoracic segmental vessels has 2 thoracic ARMAs, the first being 1 segment away from the cranial inflow region and the other being 8

segments away from the cranial inflow region, but only 2 away from the caudal inflow region, and if another patient has 2 ARMAs, one 5 segments away and the other 6 segments away, who has a higher risk of spinal ischemia if all segmental arteries are lost? We cannot answer this question today, but, given the advances in spinal magnetic resonance imaging, we should be able to answer it in the future. This is a matter of more detailed animal studies, of simulation, and of the development of risk algorithms.

ARMAs can be imaged, as one can see by a look into neuroimaging science.²³ If we can visualize ARMAs, then we need to further refine these imaging techniques and perform research that leads us to a position of being able to answer a question like the one mentioned earlier. The circle of Willis should not remain the “golden boy” of circular backup structures in the central nervous system: computationally modeled, anatomically studied by the hundreds, and described by many risk algorithms. The intraspinal arcades should not remain the “orphan” vessels, which

FIGURE 5. A different possible anatomic setting with only number and localization of ARMAs being different. ARMAs (dark blue, running horizontal) are the only interindividually variable parts of the intraspinal collateral system, with respect to number (2-12 thoracic ARMAs in humans) and to sidedness.

they are now, overlooked, unknown, not at all functionally characterized as of now. Only by putting together puzzle pieces of knowledge generated during decades of research efforts in different specialties and by moving forward with using this knowledge instead of resignation,⁴ we can understand the fascinating complexity of the intraspinal collateral flow pathways and might have modes of solid preoperative risk prediction of spinal ischemia in the future.

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ARE THERE REALLY DIFFERENCES BETWEEN ACUTE AORTIC DISSECTIONS IN EASTERN AND WESTERN POPULATIONS?

To the Editor:

We read with great interest the recent article by Wang and colleagues,¹ which reported 6 differences compared with Western dissection series reported by the International Registry of Acute Aortic Dissection (IRAD), including earlier onset, more male patients, a low incidence of hypertension, a low incidence of chest pain, great differences in the choice of therapeutic strategies, and relatively low in-hospital mortality. The authors must be congratulated for their attempt to clarify this topic: the differences between Chinese patients (the Registry of Aortic Dissection in China, Sino-RAD) and Western patients. Nevertheless, this well-illustrated work is deserving of additional comments, particularly the characteristics of type A acute aortic dissection (TA-AAD). First, patients presenting with acute aortic dissection are, on average, aged 65 years,² and patients presenting with TA-AAD are aged 60 to 64 years.³ Acute aortic dissection is relatively uncommon in young patients and usually caused by connective tissue disorders.^{2,3} The authors found onset at an earlier age compared with the data reported by IRAD in patients with TA-AAD (50.5 vs 61.1 years). It was also an earlier onset compared with the reports from the German Registry for Acute Aortic Dissection Type A (GERAADA)³

and other East Asia countries^{4,6} (Table 1). At least 30% of patients with TA-AAD were aged 70 years or more, and 5% to 8% were aged less than 40 years in the reports of IRAD,⁷ GERAADA,³ and other East Asia countries^{4,8} (Table 1). In contrast, only 4.9% were aged 70 years or more and 15.8% were aged less than 40 years according to Sino-RAD. Similar trends were also reported from large series of other reports from China^{9,10} (Table 1). Thus, it is mandatory to clarify why the Chinese population has a 1-decade disparity in age at onset. Second, the authors stated that a male predominance was even greater than in the report from IRAD.¹¹ Rylski and colleagues³ emphasized that very young patients were usually male and very old patients were usually female. Therefore, the Sino-RAD data show more young patients and male patients. Third, the authors pointed out that the ratio of patients with hypertension was low (51.4%); however, this was not demonstrated by other reports from China^{9,10} (Table 1). Reports from Korea (56.6%)⁵ and GERAADA (53%)³ also showed lower incidences. In contrast, higher incidences were reported from IRAD (70.3%),^{9,11} Japan (78.2%),⁴ and Taiwan (83.1%).⁶ Fourth, the authors reported a low incidence of chest pain (26.0%) and a high incidence of back pain (71.9%). Likewise, the incidence of anterior chest pain was not supported by the other report from China.⁹ Nevertheless, a higher incidence of back pain was found in the reports from China (71.9% in Sino-RAD¹ and 62.0% in Li and colleagues⁹) compared with the reports from Japan (50.6%),¹² IRAD (41.3%),¹³ and Taiwan (25.9%)⁸ (Table 1). Fifth, the authors reported a lower in-hospital mortality in patients with TA-AAD repair (5.3%) compared with that of IRAD (23.6%). This excellent mortality rate might be explained partly by natural selection bias and referral bias. In addition, old age was an independent predictor of in-hospital mortality²; however, only 4.9% of their patients were aged 70 years or more. Of note, preoperative shock is the most important predictor of in-hospital mortality after TA-AAD repair. A prevalence of 20% to 30% or even more of patients with TA-AAD presenting with shock has been reported (Table 1).^{4,6,7,14} However, no data on this were available in Sino-RAD. Last, there are disparities in the incidence of intramural hemorrhage or hematoma between West and East Asia,² only 3.5% from the IRAD report,¹⁵ but 27.5% in Korea,⁵ 28.9% in Taiwan,⁶ and 44.1% in Japan.¹⁶ There was no comparable intramural hemorrhage or hematoma data in the Sino-RAD, although the incidence was 2.9% reported in the other report from China.⁹

On the basis of the discrepancies between Sino-RAD and other reports from China, between Sino-RAD and other East Asia countries, and between Sino-RAD and Western series, additional research is highly recommended to clarify this unresolved and interesting issue.