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ABSTRACT

Objective: This study aims to determine whether the descending vascular axis distal to the Adamkiewicz loop is a continuation of the AKA or the ASA, using both morphological and statistical analyses.

Method: A cadaveric study was conducted on 15 adult male specimens. Following posterior access and removal of the spinal cord en bloc, low-pressure injections were performed into the ASA to visualize spinal vasculature. In several cases, the AKA was identifiable without injection due to its prominent calibre. Using digital callipers, morphometric measurements were obtained for the ascending branch, arch, and descending segment of the AKA, as well as the ASA segment proximal to the AKA loop.

Results: The mean diameter of the ASA was 1.0 mm (range: 0.5–1.86 mm), with 80% of specimens exhibiting a calibre under 1 mm. The ASA occupied less than 10% of the spinal cord's ventral surface. The AKA had a mean diameter of 1.14 mm, while the descending vascular axis measured 1.69 mm on average (range: 0.8–2.1 mm). In all specimens, the AKA presented as a continuous single trunk with ascending, arching, and descending components. The descending vascular axis showed greater morphological similarity in calibre to the AKA than to the ASA.

Conclusion: Morphometric evidence suggests that the descending spinal axis beyond the AKA loop more closely resembles a continuation of the Adamkiewicz artery rather than the anterior spinal artery.

INTRODUCTION

In the initial description of spinal cord vascularization, Lazorthes et al, reported that the ventral side of the spinal cord is vascularized by the anterior spinal artery (ASA) (5). This artery travels along the median ventral fissure from top to bottom and is reinforced along its course by various radiculomedullary arteries. At the level of the conus medullaris, the ASA anastomoses with the two dorsolateral spinal arteries, forming the anastomotic loop of the conus medullaris (3,5,11). According to this initial description, the ASA runs along the entire length of the spinal cord.

Keywords

Adamkiewicz artery,
spinal cord,
vascular anatomy



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The Adamkiewicz artery (AA) is described as an ascending artery that joins the ASA, bending to form its characteristic hairpin loop. Most authors agree that the vascular segment beyond the junction of these two arteries represents the continuation of the ASA (6,12). In fact, the Adamkiewicz artery is the main radiculomedullary artery supplying the ASA at the level of the lumbar enlargement (10,11). It is also considered the largest intradural blood supply to the anterior spinal cord (2).

We previously published an anatomical study on the ASA-AA junction and defined three types of junctions based on the diameters of the ASA, AA, and the descending branch of the ASA, which were correlated with neurological risk (7). Morphologically, the Adamkiewicz artery appears as a single trunk with an ascending branch, a loop, and a descending branch. Based on purely morphological observations, we noted trivial but consistent similarities in caliber between the Adamkiewicz artery and the descending spinal axis, more so than with the portion of the ASA proximal to the junction.

From these findings, we currently hypothesize that the descending spinal axis beyond the Adamkiewicz loop may be more accurately described as the continuation of the Adamkiewicz artery rather than the ASA. The present study aims to determine the true origin of the descending spinal axis following the Adamkiewicz loop through both morphological and statistical analysis.

MATERIAL AND METHOD

A cadaveric study was conducted on a series of 15 adult male specimens. The vertebral column was accessed via a posterior approach (Fig. 1), and the spinal cords were meticulously excised en bloc following bilateral resection of the nerve root attachments. The anterior dura was then incised to allow for low-pressure injection into the anterior spinal artery (ASA), which was readily identifiable within the median ventral fissure. This injection enabled clear visualization of the radiculomedullary arteries, including the artery of Adamkiewicz. Notably, in several specimens, the Adamkiewicz artery could be identified without ASA injection due to its distinctive caliber (Fig. 2).

Using a digital caliper, precise morphometric measurements were obtained for critical segments of the Adamkiewicz artery. These included the diameter of the ascending branch, the curvature of

its characteristic hairpin loop, the diameter of the anterior spinal artery (ASA) segment proximal to the loop, and the vertical arterial segment extending distally from the arch (Fig. 3).

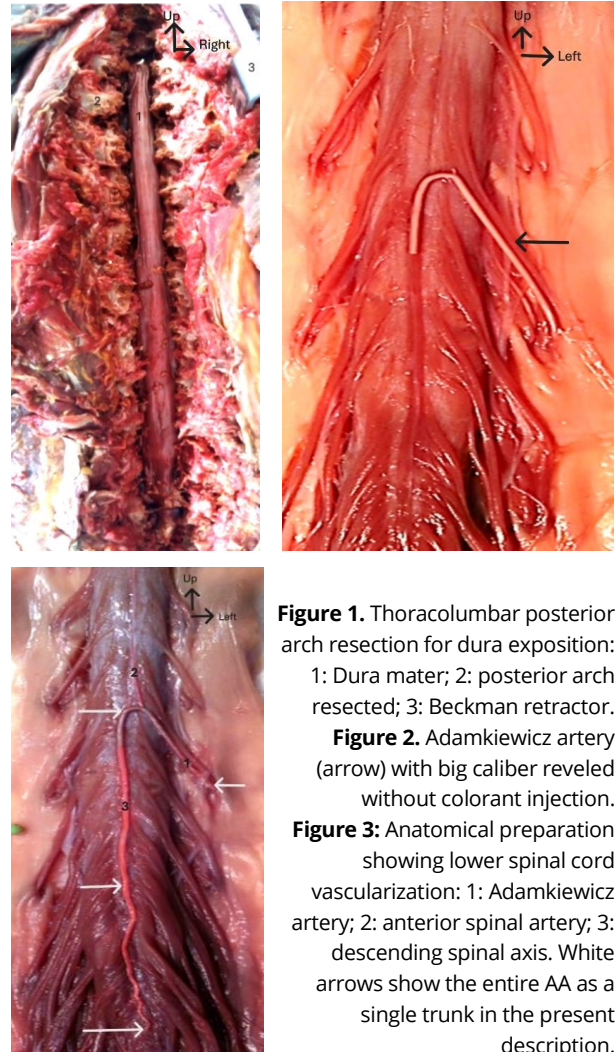


Figure 1. Thoracolumbar posterior arch resection for dura exposition: 1: Dura mater; 2: posterior arch resected; 3: Beckman retractor.

Figure 2. Adamkiewicz artery (arrow) with big caliber revealed without colorant injection.

Figure 3: Anatomical preparation showing lower spinal cord vascularization: 1: Adamkiewicz artery; 2: anterior spinal artery; 3: descending spinal axis. White arrows show the entire AA as a single trunk in the present description.

RESULTS

The average diameter of the anterior spinal artery (ASA) was 1.0 mm, with a range from 0.5 mm to 1.86 mm. In 80% of specimens, the ASA caliber was less than 1 mm. The artery occupied less than 10% of the ventral surface of the spinal cord, which measured an average width of 9.4 mm (ranging from 8 mm to 14 mm). Table 1 summarizes the ASA caliber, AA caliber and the vertical axis after AA loop caliber spinal cord surface, and the percentage of ventral surface covered by the ASA and the AA.

Morphometric analysis of the Adamkiewicz artery (AA) revealed a mean diameter of 1.14 mm at its middle third, with the majority of specimens

exhibiting a diameter greater than 1 mm. The descending vascular axis distal to the Adamkiewicz arch measured an average of 1.69 mm, with observed extremes ranging from 0.8 mm to 2.1 mm. In all specimens, the Adamkiewicz artery consistently appeared as a single-trunk vessel, comprising an ascending branch, a transverse arch, and a descending axis.

DISCUSSION

The anterior spinal artery, the Adamkiewicz artery, and the radiculomedullary arteries share a closely related embryological origin. The ASA consistently exhibits a relatively small diameter, averaging around 1 mm, which aligns with the findings of Ko *et al.* in their anatomical study of 15 specimens (4). Suh *et al.*, in a separate study involving 26 specimens, reported a mean ASA diameter of approximately 0.57 mm (9).

In our study, the intradural portion of the Adamkiewicz artery demonstrated an average diameter of 1.14 mm, consistent with measurements reported by Beaza *et al.* (8). The descending vascular axis distal to the AA's arch measured 1.69 mm in diameter. In a meta-analysis of 375 patients, Tattera *et al.* found that in 71.3% of cases, the AA formed a continuous conduit from the aorta to the ASA (12).

To address our initial hypothesis, a morphological comparison was undertaken. The aim was to evaluate the diameter of the descending vascular axis in relation to both the ASA and the AA. It was observed that the descending vascular axis was, on average, 1.84 times larger in diameter than the ASA, and 1.5 times larger than the AA. In a previous investigation, we noted that the diameter of the descending segment closely matched that of the AA at the level of its arch; however, no definitive hypothesis was proposed regarding its origin (7).

A detailed statistical analysis using the Wilcoxon test for paired samples ($\alpha = 0.05$) revealed a statistically significant morphological difference between the descending vascular axis and the ASA ($p = 0.003$), as well as between the descending vascular axis and the AA ($p = 0.001$). Notably, the caliber of the descending axis appeared to diverge from that of the ASA, while approximating the caliber of the AA.

Subsequent bivariate analysis indicated that the difference in caliber between the descending axis and the AA ($p = 0.300$), as well as between the descending axis and the ASA ($p = 0.407$), was not

statistically significant. However, correlation analysis revealed a stronger association between the descending vascular axis and the AA ($r = 0.287$) compared to the ASA ($r = 0.208$). Based on these morphological and statistical findings, the descending vascular axis appears to share greater similarity with the AA than with the ASA.

Furthermore, all anatomical specimens consistently displayed the Adamkiewicz artery as a single, uninterrupted trunk of large caliber extending from its dural penetration to its distal termination. These preparations also revealed that the ASA terminated at the apex of the AA loop centrally within the ventral median fissure in 10% of cases and laterally in the remainder. This finding supports the notion that the ASA may represent a chain of anastomoses terminating at the apex of the AA loop.

In a cadaveric study, Alleyne *et al.* described the intradural segment of the AA referred to as the "medial trunk" as a single continuous vessel following its junction with the ASA (1). The concept of the AA as a singular, dominant trunk challenges the traditional depiction of spinal cord vascular anatomy. However, it offers a compelling explanation for the profound neurological deficits associated with injury to the AA, which would compromise vascular supply to the entire lower spinal cord.

Table 1. Morphometric features of AA, ASA and vertical vascular axis.

Spec	AA	ASA	Vert Ax	Cord surf	AAs (%)	ASAs (%)	Vert Axis (%)
1	0.80	1	0.80	9	8.89	11.11	8.89
2	1.12	1.12	1.50	9	12.44	12.44	16.66
3	1.26	0.60	1.20	9	14	6.67	13.33
4	0.61	1.20	1.53	8	7.62	15	19.12
5	1.77	1.86	1.86	14	12.64	13.29	12.64
6	1.90	1.50	2.10	10	19	15	21
7	0.90	1	2	10	9	10	20
8	1.20	0.8	1.25	9	13.33	8.89	13.88
9	0.80	0.5	2	9.5	8.42	5.26	21.05
10	0.90	1	1.90	9	9	11.11	21.11
11	1.20	0.75	1.70	9	13.33	8.33	18.88
12	1.10	1	1.85	8.5	12.94	11.76	21.76
13	1.15	0.95	1.80	9	12.77	10.56	20
14	1.20	1	2	8	15	12.50	25
15	1.12	0.75	1.90	10	11.2	7.50	19

AA= Adamkiewicz artery, ASA= anterior spinal artery, Vert AX= vertical axis, Cord surf= spinal cord surface,

AAs= Adamkiewicz artery projection on spinal cord surface,
 ASAs= anterior spinal artery projection on spinal cord surface,
 Vert Axs= Vertical axis projection on spinal cord surface.

CONCLUSION

In light of this descriptive anatomical study, the Adamkiewicz artery (AA) consistently appeared as a single, uninterrupted trunk. After perforating the dura mater, it exhibited an initial extramedullary ascending segment, ultimately giving rise to a descending branch closely adherent to the median ventral fissure of the spinal cord. Morphologically, the descending vascular axis appears to represent a continuation of the AA rather than a segment of the ASA. These findings suggest that the AA serves as a critical conduit connecting the anterior and posterior medullary vascular territories.

This unique arterial configuration may explain the profound neurological deficits frequently observed following injury to the AA, as such damage compromises blood flow to a substantial portion of the spinal cord. Nevertheless, this conclusion remains a preliminary hypothesis and warrants validation through studies involving larger sample sizes.

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