

ORIGINAL ARTICLE

Anatomical study of blood supply to the spinal cord in the rabbit

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Study design: The study was carried out in rabbit.

Objective: To investigate the arterial blood supply of the spinal cord in rabbit as model in experimental spinal cord ischemia surgery.

Setting: The study was carried out in the Department of Anatomy, Histology and Physiology, University of Veterinary Medicine and Pharmacy in Kosice, Slovak Republic.

Methods: The study was carried out on 10 adult New Zealand white rabbits. We prepared corrosion casts of arterial system of spinal cord. Batson's corrosion casting kit no. 17 was used as a casting medium.

Results: The presence of branches entering *arteria spinalis ventralis* in the thoracic region was observed in 71% of the cases on the left side and in 29% on the right side. In the lumbar region, left-sided branches were observed in 52% of the cases and right-sided in 48% of the cases. The artery of Adamkiewicz was present in 50% of the cases as left-sided and in 50% as right-sided.

Conclusion: Documenting the anatomical variations in spinal cord blood supply in the rabbit will aid in the planning of future experimental studies and determining the clinical relevance on such studies.

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Keywords: rabbit; blood supply; the artery of Adamkiewicz; origin

Introduction

Experimental studies on animals and detailed knowledge of anatomy of the spinal cord blood supply with all existing variations can contribute to the protection of the spinal cord.

Rabbits are laboratory animals frequently used in studies of the spinal cord ischemia damage. Not many studies have dealt with arterial supply of the spinal cord in the rabbit.¹ High variability of spinal cord feeding arteries was infallibly demonstrated in several species but was probably best documented in man.^{2–7}

The aim of this study was to contribute to the knowledge of arterial supply of the spinal cord of rabbits, with focus on thoracic and lumbar regions in which the surgical procedures are associated with the risk of serious neurological damage. At the same time, we would like to point to some variations in segmental arterial supply of the spinal cord in the respective regions.

Materials and methods

The study was carried out on 10 adult (age=140 days) New Zealand white rabbits (breed HY+), females ($n=5$) and males ($n=5$) of mean weight 2.5–3 kg in an accredited experimental laboratory at the University of Veterinary Medicine in Kosice, Slovakia Republic. The animals were kept in cages under standard conditions (temperature 15–20 °C, relative humidity 45%, 12 h light period) and fed granular mixed feed (O-10 NORM TYP, Spišské krmné zmesi, Spišské Vlachy, Slovak Republic). Drinking water was provided *ad libitum*. The animals were killed by prolonged inhalation anesthesia with ether. Immediately after killing, the vascular network was perfused with saline. During the manual injection through an ascending aorta, the right vestibule was opened to lower the pressure in the vessels to ensure good injection. Batson's corrosion casting kit no. 17 in quantity of 50 ml (Dione, České Budějovice, Czech Republic) was used as a casting medium. After polymerization of the medium (1 h), 10 % formaldehyde was injected into the vertebral canal between the last lumbar vertebra and sacrum to fix the spinal cord. After 24 h fixation, the vertebral canal was opened by removing vertebral arches in the thoracic, lumbar and sacral spinal regions. The prepared spinal cord was fixed in 10% formaldehyde. We certify that all applicable institutional and governmental regulations

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concerning the ethical use of animals were followed during the course of this research.

Results

The spinal cord receives blood from the arteria spinalis ventralis, which runs subdurally in the ventral median fissure of the spinal cord is present in humans, known as the arteria spinalis anterior. In the thoracic and lumbar regions, it receives strengthening branches from intercostal and lumbar arteries (Figures 1 and 2). They enter the vertebral canal through the foramen intervertebrale in association with the respective spinal nerve root. After entering the vertebral canal, they send to the spinal cord ramus spinalis, which is divided into dorsal and ventral branches. The ventral branch enters the arteria spinalis ventralis. The frequency of occurrence of individual segmental arteries is shown in Table 1. The presence of branches entering the

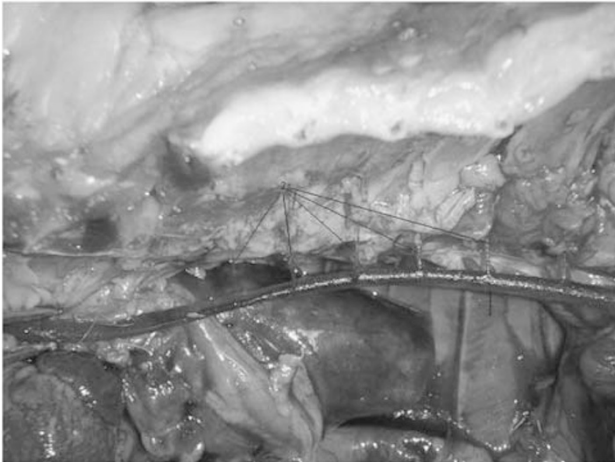


Figure 1 Arteriae intercostales dorsales as segmental branches of aorta thoracica. (1): Aorta thoracica and (2): arteriae intercostales dorsales. Lateral view. Macroscopic image.



Figure 2 Arteriae lumbales as segmental branches of aorta abdominalis. (1): Aorta abdominalis and (2): arteriae lumbales. Lateral view. Macroscopic image.

arteria spinalis ventralis in the thoracic region was observed in 71% of the cases on the left side and in 29% on the right side. In the lumbar region, left-sided branches were observed in 52% of the cases and right-sided in 48% of the cases. Along the entire thoracic and lumbar spinal regions, we observed left-sided branches in 62.5% and right-sided in 37.5% of the cases (Figure 3), which is most likely related to left-sided localization of the aorta.

In addition to relatively small and weak segmental spinal arteries, we also observed a bigger feeding artery arising from the spinal branch of the sixth lumbar artery, entering vertebral canal through the foramen intervertebrale and passing into the arteria spinalis ventralis. This artery termed the arteria radicularis magna or the artery of Adamkiewicz was present in all cases. In 50% of the cases, this artery was left sided (Figure 4) and in 50% right sided (Figure 5). The artery of Adamkiewicz supplies the spinal cord caudally from the point of narrowing of the arteria spinalis ventralis in the lumbar region. After reaching the fissura mediana ventralis, it runs caudally replacing the arteria spinalis ventralis and sends an important branch cranially to the thinning arteria spinalis ventralis (Figure 4).

Discussion

Observations in the rabbit confirmed high variability of segmental arteries supplying blood to the spinal cord. On the left side, they occurred in higher number with more uniform distribution. Arteries in the thoracic and lumbar regions ensured segmental supply of the respective sections of the arteria spinalis ventralis and, thus, also the caudal two-thirds of the rabbit spinal cord. This is the reason why the rabbit can be partially used for simulation of spinal cord ischemia in man. Segmental arteries in the thoracic region occurred

Table 1 Frequency of occurrence of spinal arteries in the thoracic and lumbar regions of spinal cord

<i>Frequency of occurrence of spinal arteries (%)</i>		
<i>Level</i>	<i>Right</i>	<i>Left</i>
Th 1	0	50
Th 2	25	50
Th 3	25	0
Th 4	0	50
Th 5	0	75
Th 6	25	75
Th 7	25	25
Th 8	0	50
Th 9	25	0
Th 10	25	50
Th 11	25	0
Th 12	25	25
Th 13	25	75
L 1	50	50
L 2	25	25
L 3	50	50
L 4	75	75
L 5	50	75
L 6	50	50

Abbreviations: L, lumbar segment of the spinal cord; Th, thoracic segment of the spinal cord.

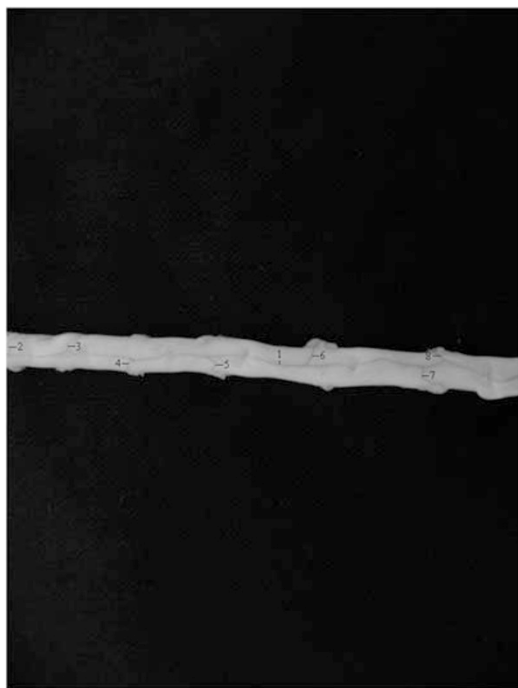


Figure 3 Segmental branches entering arteria spinalis ventralis. (1): Arteria spinalis ventralis, (2): ventral branch of ramus spinalis arteriae intercostalis dorsalis V sinistrae, (3): ventral branch of ramus spinalis arteriae intercostalis dorsalis VI sinistrae, (4): ventral branch of ramus spinalis arteriae intercostalis dorsalis VII dextrae, (5): ventral branch of ramus spinalis arteriae intercostalis dorsalis IX dextrae, (6): ventral branch of ramus spinalis arteriae intercostalis dorsalis XI sinistrae, (7): ventral branch of ramus spinalis arteriae intercostalis dorsalis XIII dextrae and (8): ventral branch of ramus spinalis arteriae intercostalis dorsalis XIII sinistrae. Ventral view. Macroscopic image.



Figure 4 Left-sided localization of the Adamkiewicz artery. (1): Arteria spinalis ventralis, (2): Adamkiewicz artery, (3): branch of Adamkiewicz artery running cranially and (4): ventral branch of ramus spinalis arteriae lumbalis V dextrae. Ventral view. Macroscopic image.

irregularly, and their absence was noted more frequently than in the lumbar region, which allowed us to assume higher risk of irreparable ischemic damage to the thoracic region of the spinal cord in the rabbit.

It is well known that contrary to other laboratory animals, the blood supply to the spinal cord of rabbits is homoseg-



Figure 5 Right-sided localization of Adamkiewicz artery. (1): Arteria spinalis ventralis and (2): Adamkiewicz artery. Ventral view. Macroscopic image.

mental, that is, each spinal cord segment is supplied with one corresponding radicular artery with minimal or none collateral bloodstream. Till now, it has been published works only dealing with the description of the spinal cord blood supply of rabbits.¹ In this work, the presence of the artery of Adamkiewicz, or the level of its origin as well as variations of spinal cord blood supply in the rabbit have not been described. In the study of the spinal cord, ischemic injury was used as experimental model dogs, rats, pigs and mice. In dog, the artery of Adamkiewicz was present only in half of all the specimens.⁸ In rats, many authors found the artery of Adamkiewicz in all the studied specimens,^{1,9-11} but many works doubt the presence of the artery of Adamkiewicz.^{12,13} In pig, variations and presence of extrasegmental arteries of the spinal cord blood supply were described.^{14,15} In the mouse, the artery of Adamkiewicz was also present.¹⁶ In all species, thoracic and lumbar regions segmental arteries were present. The artery of Adamkiewicz, regularly observed in man in whom it supplies the spinal cord caudally from the point of narrowing of the arteria spinalis ventralis, was present in all the cases.¹⁷

The presence of the artery of Adamkiewicz in all our studied animals and its more caudal origin are responsible for the use of rabbit as a simple model of ischemic damage to the caudal half of the spinal cord. The using of rabbit in study of spinal cord ischemic injury is technically advantageous than in the mouse or rat, because of the bodily proportions of these two species and there are some studies that make the presence of the artery of Adamkiewicz in rats questionable. In comparison with dogs, the use of rabbits in experiments is less expensive.

Documenting the anatomical variations in the spinal cord blood supply in the rabbit will aid in the planning of future experimental studies and determining the clinical relevance on such studies.

Conflict of interest

The authors declare no conflict of interest.

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