MORPHOLOGY OF THE LUMBAR ARTERIES

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ÖZET
Lumbal Arterlerin Morfolojisi

Torakoabdominal aorta'nın replasmanı süresince, Adamkiewicz arterinin muhtemel orijin yerini ortaya çıkaran lumbal arterlerin korunmasının önemi tartışıldı. Bu çalışmanın amacı, lumbal arterlerin morfolojisini incelemek ve onların klinik önemini belirlemektir.

Gülhane Askeri Tıp Akademisi Askeri Tıp Fakültesi'nin Anatomi laboratuvarından elde edilen 10 erkek ve 5 kadın kadavrayı disseke ettik. Kadavra yaşları, kırk ile yetmiş arasında bir dağılım gösteriyordu ve ortalama 52 idi. Biz ilk önce aortik bifurkasyonun seviyesini belirledik ve daha sonra lumbal arterlerin orijin noktalarının aortik bifurkasyona olan uzaklıklarını ölçtük. Sağ ve sol lumbal arterlerin orijin seviyeleri, çapları birbirleri arasındaki uzaklığı ve ayrıca abdominal aorta'nın çapını ölçtük.

Abdominal aortanın çapı ile sağ ve sol lumbal arterlerin çaplarının oranını ve istatistiksel olarak önemini ortaya koyduk. Bununla birlikte bu ilişkili değerlerden, sadece sol ikinci lumbal arterin çapının önemli olduğunu belirledik. Buna ek olarak, sol ve sağ lumbal arterin çaplarının oranını ve farklılığını istatistiksel olarak önemsiz bulduk. Ayrıca, sağ ve sol lumbal arterin abdominal aorta'dan orijin seviyelerinin oranı ve miktarı arasındaki farklılığın istatistiksel olarak önemi belirlendi. Bu oranlar karşılaştırılarak, 4. lumbal arterin 2. ve 3. lumbal arterden farklı olduğu gözlendi. Dört kadavrada ise 5. çift lumbal arter saptandı.

Sonuç olarak, lumbal arterlerin yerleşimlerinin, çaplarının ve her bir çiftin arasındaki uzaklığın farklı olduğu belirlendi. Ayrıca, bazen her bir çiftin abdominal aortanın gövdesinden orijinlendiği görüldü. Tüm veriler istatistiksel olarak değerlendirildi ve lumbal arterlerin morfolojisinde farklılıklar saptandı. Bu farklılıkların, Adamkiewicz arterinin lumbal arterlerden orijin alıp almamasına göre değişip değişmediği tartışıldı. Bu farklılıkların, klinik öneminin olabileceği vurgulandı. Aort anevrizması, disk hernisi ve spinal kord tümörleri operasyonları süresince Adamkiewicz arterinin anatomik önemi ve interkostal ve/veya lumbal arterlerle ilişkisinin postoperatif paraplejinin önlenmesinde önemli olduğu anlaşıldı.

Anahtar Kelimeler:*Arteriae Lumbales, Adamkiewicz Arteri, Arteria Sacralis Mediana, 5. Arteria Lumbalis.*

SUMMARY

Purpose:*The importance of preserving Adamkiewicz artery which originates in the lumbar artery during replacement of the thoracoabdominal aorta is debated.*

The purpose of the present study is to examine the morphology of lumbar arteries and to determine their clinical importance.

Methods: *We dissected 10 male and 5 female cadavers obtained from the anatomy laboratory of the Medical School of the Gulhane Military Medical Academy. The age of the cadavers ranged from 40 to 70 years, average age 52. After having determined the level of aortic bifurcation, we measured the distance from that point to the origin of the lumbar arteries. Right and left lumbar arteries origin levels, diameters and the distance between them, as well as abdominal aorta diameter were measured.*

Results: *The comparison of the diameters of the right and left lumbar arteries with diameter of the abdominal aorta was found to be statistically significant, also, the difference in the diameter of the second left lumbar artery was found to be significantly different from the other left lumbar arteries. However, we did not find a statistically significant difference and ratio diameters of the left and right lumbar arteries. Furthermore, we determined as statistically significant the distance between the left renal artery and the right and left lumbar arteries at the level of the abdominal aorta. We established that the difference between the second and third lumbar arteries of the fourth lumbar artery pair was statistically different. The lumbar arteries were observed in five pairs in four cadavers.*

Conclusion: *In conclusion, it was observed that they had different locations and, diameters, and that distances between each pair were different. It was also seen that each pair sometimes originated from the common trunk of the abdominal aorta. All data were evaluated statistically and morphological differences were found in the morphology of lumbar arteries and it is believed that these differences may be of clinical importance. During operations for aortal aneurysm,*

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disc hernia and tumors of spinal cord, detailed anatomical knowledge of the Adamkiewicz artery and its correlation with the intercostals and/or lumbar arteries is important to prevent postoperative paraplegia.

Key Words: *Lumbar Arteries, Adamkiewicz Artery, Median Sacral Artery, Fifth Lumbar Artery.*

INTRODUCTION

It is considered crucial to know the morphology of the arteries which arise from the eighth and twelfth thoracic vertebrae and the first and second lumbar vertebrae, and especially the greater radicular artery (Adamkiewicz artery) before surgery for aortal aneurysms, disc hernias and tumors of spinal cord. The purpose of this study was to define relationship between the lumbar arteries that occasionally arise from the Adamkiewicz artery.

Many researchers have defined neurological complications that appear to depend on retroperitoneal vascular lesions during operations on the thoracoabdominal aorta aneurysm and lumbar vertebral disc surgery (1).

The importance of preserving Adamkiewicz artery that originates in the lumbar artery during replacement of the thoracoabdominal aorta is debated. The largest radiculospinal artery is the artery of Adamkiewicz, which arises from a lower intercostals artery or upper lumbar artery on the left side and supplies the lumbar enlargement and conus medullaris. The artery of Adamkiewicz has to be borne in mind by the vascular surgeon attempting to deal with an abdominal aortic aneurysm. If a clamp is placed across the aorta and the artery happens to arise from below that level, the patient is at risk of postoperative paraplegia (1).

Anatomical knowledge of the spinal cord arterial blood supply is crucial for the therapeutic approach to spinal vascular malformations in interventional neuroradiology, as well as for selective screening of the anterior spinal artery in prevention of post-operative neurological complications following surgery on the upper lumbar spine or abdominal aorta (2).

Lumbar arteries arise posterolaterally from the aorta opposite the lumbar vertebrae, usually four on each side. Each lumbar artery has a dorsal branch, and supplies the dorsal muscles, joints and skin. This dorsal branch also has a spinal branch entering the vertebral canal to supply its contents and adjacent vertebra. The first spinal branch supplies the terminal spinal cord itself: the remainder supply the cauda equine, meninges and vertebral canal (3).

The Adamkiewicz artery supplies most of the blood to the anterior spinal artery, which perfuse the anterior two thirds of the spinal cord. During operations for thoracoabdominal aortic aneurysm, detailed anatomical knowledge of the Adamkiewicz artery and its correlation with the intercostals and lumbar arteries is important to prevent postoperative paraplegia (4).

Injury to the artery of Adamkiewicz can result in devastating ischemia of the lower spinal cord (5).

None of these factors proved to be significant as the sole cause of spinal cord ischemia. Spinal cord ischemia after abdominal aortic operations appears to be a tragically unpredictable, random, and unpreventable event (6).

Thirty or so branches of the dorsal aorta, the dorsal intersegmental arteries, pass between and carry blood to the somites and their derivatives. Most of the dorsal intersegmental arteries in the abdominal become lumbar arteries, but the fifth pair of lumbar intersegmental arteries remains as the common iliac arteries. The caudal end of the dorsal aorta becomes the median sacral artery (7). The segmental feeders are a branch of the dorso-lateral somatic intersegmental arteries originating from the aorta. In the thoracic and upper lumbar regions, the intersegmental arteries persist as intercostals and lumbar arteries (8). The segmental arteries of the thoracolumbar region are preserved as the lumbar and intercostals arteries (9).

This study will help in the planning of surgical and end vascular stint-graft repair of thoracic aortic aneurysms and may help prevent some neurological deficit.

MATERIALS AND METHODS

We dissected 10 male and 5 female cadavers obtained from the anatomy laboratory of the Medical School of the Gulhane Military Medical Academy. The age of the cadavers ranged from 40 to 70 years, and average age 52. We approached the posterior wall of the abdomen by routine dissection methods, and the abdominal aorta and its related branches were cleaned for good visibility. Measurements were made with a micrometer using the abdominal aorta bifurcates, anterior lateral to the left side of the fourth lumbar vertebral body, and the right and left common iliac arteries as the reference points.

All measurements showed in the Figure 1 were performed and recorded by the authors and a sketch of the vascular anatomy was made after each dissection was completed. The width of each artery studied was measured at its origin by flattening the artery on a hard surface. The total measurements were approximately taken using a millimetric caliper due to 37 % formaldehyde.

FIGURE LEGENDS

Figure 1: Measurements of Anatomical Distances

Measurements of anatomical distances / mm	Case				
	Right	Diameter of the right	Distance	Left	Diameter of the left
The level of the aortic bifurcation (from the upper edge of the fourth lumbar vertebra)					
Distance from median sacral artery from the aortic bifurcation					
Distance between fourth lumbar artery and the aortic bifurcation					
Distance between third lumbar artery and the aortic bifurcation					
Distance between second lumbar artery and the aortic bifurcation					
Distance between first lumbar artery and the aortic bifurcation					
Existence and position of the fifth lumbar artery					
Diameter of the abdominal aorta					
Feature	Sex, Age				

The diameter of the abdominal aorta was measured at the level fifty millimeters above the aortic bifurcation. The level of the aortic bifurcation was determined and the distance to the upper edge of the fourth lumbar vertebra was measured. The distance from the exit of the median sacral artery to the aortic bifurcation was also measured. The exit level upper edge of the fourth, third, second and first lumbar arteries were measured from the aortic bifurcation. The one piece of the lumbar artery which had been cut at the exit point from the abdominal aorta was placed on a flat place. The diameters of these arteries were measured inner diameter by two plane crossing each other, and were taken average two measure. A fifth, smaller pair of lumbar arteries occasionally arises from the median sacral artery and we searched for the presence and the origination of these arteries in all cadavers studied.

Statistical analysis:

All statistical analyses were performed with the SPSS 10.0 package (SPSS for Windows; SPSS Inc., Chicago, ILL. U.S.A.). All values are given as the mean ± standard deviation. In addition to the tests of normality, we used Friedman's test to investigate the differences between the arteries. Then, we used Wilcoxon signed rank test (with Bonferroni correction) for pairwise comparisons. We also used the Spearman ranks correlation coefficient to study the relationship between the diameter value of the lumbar arteries and the abdominal aorta. p values less than or equal to 0.05 were evaluated as statistically significant.

Figure 2: Illustration made during dissection. The each cadaver was seen by "T" letter. The study done on fifteen cadavers determined eleven different groups.

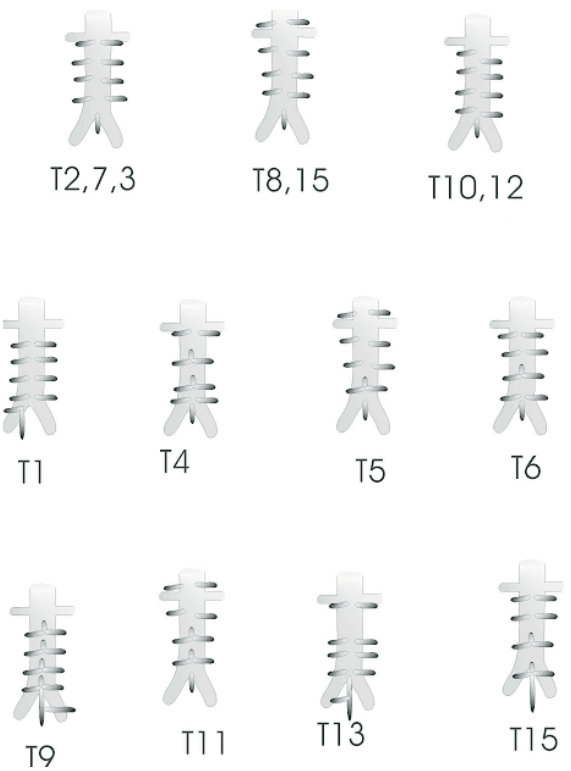

Table - I: The minimum, maximum, mean and standard deviation value of the descriptives of the variables used in the study.

Variables measured in mm	Minimum	Maximum	Mean	Standard deviation
Origin level of the right first lumbar artery	74.7	103.7	92.77	10.46
Origin level of the left first lumbar artery	74.7	106.7	94.91	10.55
Origin level of the right second lumbar artery	46.8	78.6	63.96	9.52
Origin level of the left second lumbar artery	46.8	85.0	65.95	10.50
Origin level of the right third lumbar artery	25.9	48.8	39.02	7.48
Origin level of the left third lumbar artery	25.9	50.6	40.11	8.13
Origin level of the right fourth lumbar artery	8.7	27.4	17.76	5.97
Origin level of the left fourth lumbar artery	8.7	27.4	17.95	6.14
Distance between first lumbar arteries	0	8.5	4.03	2.43
Distance between second lumbar arteries	0	8.0	3.95	2.16
Distance between third lumbar arteries	0	7.7	3.39	3.00
Distance between fourth lumbar arteries	0	5.0	1.16	1.25
Diameter of the right first lumbar artery	1	4.2	2.57	1.00
Diameter of the left first lumbar artery	1.4	3.3	2.13	0.55
Diameter of the right second lumbar artery	1.0	4.0	2.12	0.82
Diameter of the left second lumbar artery	1.0	3.0	1.79	0.59
Diameter of the right third lumbar artery	1.1	3.7	2.25	0.66
Diameter of the left third lumbar artery	1.4	3.9	2.29	0.61
Diameter of the right fourth lumbar artery	1.0	4.6	2.37	1.02
Diameter of the left fourth lumbar artery	1.0	4.0	2.17	0.74
Aortic bifurcation	6.0	12.0	9.02	1.99
Diameter of the abdominal aorta	8.0	22.0	14.86	3.36

RESULTS

Table-I shows the minimum, maximum, mean and standard deviations of all variables. Figure 2 shows an illustration made during dissection. The comparisons of diameter and length values are in Table-II. The distance between the right and the left lumbar arteries was evaluated as statistically significant, however, the difference between the diameters of the right and the left lumbar arteries was not significant. The entire right and left lumbar arteries were determined to be different from each other as seen in Table-II. In addition, the distance between the first, second and fourth lumbar arteries was significantly different. The unit of all values measuring Table-I and II was millimetre.

Table - II : Comparisons results of the diameters and the lengths

	χ^2	p
Origin level of the right lumbar arteries	45.000	<0.001
Diameter of the right lumbar arteries	2.250	0.522
Distance between lumbar arteries	15.882	0.001
Origin level of the left lumbar arteries	45.000	<0.001
Diameter of the left lumbar arteries	6.308	0.098

We searched for the level of the aortic bifurcation in each cadaver as seen in classic anatomy textbooks. The upper edge of the fourth lumbar vertebrae was used as the reference point. The level of the aortic bifurcation was measured through this point. This point was determined to be below this level in eight cadavers and above in seven cadavers.

While the starting point of the median sacral artery was 6-12 mm (mean of 9 mm ± SD) below the aortic bifurcation in 13 cadavers, it was different in two cadavers. In one case, this artery originated from 9.4 mm below the fourth lumbar artery, and in another one it originated from the same locations as the fourth lumbar artery.

In this study, the fifth lumbar artery and its origin were investigated. Four cadavers out of 15 were found to have this artery. These arteries in one cadaver were unilateral, and in three cadavers bilateral. They originated from below the bifurcation aorta, and above the median sacral artery. Diameter of the abdominal aorta 50 mm above the aortic bifurcation was measured as 8-22 mm (mean 14.86 mm ± SD).

When we compared the diameter of the abdominal aorta and right lumbar arteries, it was seen that there were statistics significant relations between only the second and third lumbar arteries (respec-

tively r =0.606; p =0.017 and r =0.535; p =0.040). The diameter of the abdominal aorta increased and the diameter of the right 2nd and 3rd lumbar arteries also increased. When we investigated the correlation between the left lumbar arteries and abdominal aorta, it was seen that there was a positive correlation between the second, third and fourth lumbar arteries and the abdominal artery and the abdominal aorta. There was a significant relationship only between the second lumbar artery and abdominal aorta (r=0.671; p=0.006).

Additionally, there was no statistics significant difference between the diameter of the right and the left lumbar arteries (χ^2 = 5.322; p = 0.150). When we compared the origin point on the abdominal aorta of the right and left lumbar arteries, it was observed that there was a statistically significant difference between them (χ^2 = 10.410; p = 0.015). For pairwise comparison, the fourth lumbar artery apart from second and third lumbar arteries were seen. (respectively z = 2.271; p = 0.023 and z = 2.134; p = 0.033).

DISCUSSION

In this study, we aim to investigate lumbar arteries, which might be injured during the surgery of the thoracoabdominal aorta aneurysm and disc hernia. Many authors have investigated this subject and mentioned that Adamkiewicz artery which supplies two thirds of the lower spinal cord may originate from upper lumbar arteries (2, 4, 9, 10, 11, 12, 13, 14, 15).

According to Takase et al., the entrance level of this artery was located exceptionally low at L1 to 3 (16), and Lo et al. reported three cases with the unusual origin of the artery of Adamkiewicz from the fourth lumbar artery (2). Neubauer reports on the cases of retroperitoneal vascular lesions during lumbar vertebral disc surgery. The author discussed the importance of the origin level of the Adamkiewicz artery and also explained the importance of noting the existence of the fifth lumbar artery to prevent retroperitoneal vascular lesions (10). Jellinger et al. explained the Adamkiewicz artery origin was seldom in the lower lumbar region (26.2 %) (11), Illuminati et al. stated that it originated from a lumbar artery between L1 and L2 in 6 cases (21.4%) (17). The Adamkiewicz artery arose from between T8 and L1 (86.2%) (18). The entrance level of this artery was located between T9 and 12, exceptionally high between T6 to 8 or low at L1 to 3 (9).

In the thoracolumbar region, one of the anterior radicular arteries is always distinctly dominant in caliber and was therefore termed to be the greater radicular artery by Adamkiewicz (11). There was no statistically significant correlation between the diameter of the Adamkiewicz artery and that of intercostals and/or lumbar arteries (4).

When comparing diameters of the abdominal aorta with right and left lumbar arteries, we have not encountered a significant relationship between them. It was observed that the diameters of the right and the left lumbar arteries increased when the diameters of the abdominal aorta increased. Additionally, the diameters of the right and the left lumbar arteries were compared and the difference between them was not statistically significant.

Thron stated that 2/3 of the spinal cord was supplied by the Adamkiewicz artery which originated between T9-T12 on the left side in 73% of cases (9).

Illuminati et al. stated that in only 5 of 28 cases this artery originated from the right side (18).

Takase et al. stated that fifty-five arteries of Adamkiewicz (71%) originated from the left side (16), and in 23 (82.1%) cases it originated from the left side, while only in 5 (17.9) from the right side (17). Approximately 70% of the Adamkiewicz arteries originated from the intercostals and/or lumbar arteries on the left side (4).

In our study, we compared the starting point of the left and right lumbar arteries from the abdominal aorta and observed that the difference between them was statistically significant. For pairwise comparison, the fourth lumbar artery apart from second and third lumbar arteries were seen.

It is difficult to investigate the Adamkiewicz artery by using dissection methods. This artery was easily investigated by using selective angiographies, medullar angiographies, MR angiographies and CT by many researchers (14, 15, 16, 17, 18, 19, 20, 21).

Takase et al. stated that best method noninvasive detection of the artery of Adamkiewicz is magnetic resonance (MR) imaging and multi-detector row helical computed topography (CT) (16). Spinal cord arteriography (SCA) is a safe adjunct that warrants more widespread use in the management of descending thoracic or thoracoabdominal aortic aneurysms (18, 20). Yamada et al. said that preoperative detection of the Adamkiewicz artery was possible using MRI (15, 19). Illuminati et al. defined the origin of the medullar artery through medullar angiographies in order to prevent paraplegia during surgery of the thoracoabdominal aorta (17). Fereshetian et al. used intra-arterial digital subtraction angiographies (DSA) for preoperative localization of the anterior spinal artery in 12 patients (14). Heinemann et al. said that selective angiographies

could demonstrate the spinal cord blood supply even in patients with complex aortic pathology (21).

In this study, we investigated starting point of the lumbar arteries from the abdominal aorta by dissecting the arteries and measuring diameters. Finally, we compared the results.

The purpose of this work was to investigate the morphology of the lumbar arteries and their clinical importance as a preoperative study of thoracic aortic aneurysm to prevent ischemic injury of the spinal cord. This study provides evidence that, during operations on the thoracoabdominal aorta and anterior thoracolumbar stabilization, the intercostals and/or lumbar arteries should be preserved, regardless of their diameters, to prevent postoperative paraplegia.

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