EXTRAFORAMINAL LUMBAR ARTERIAL ANATOMY

Sukru Caglar, M.D.,* Habibullah Dolgun, M.D.,* Hasan Caglar Ugur, M.D.,* Fuat Torun, M.D.,* Ayhan Attar, M.D.,* Aysun Uz, M.D.,† Ibrahim Tekdemir, M.D.,† and Alaittin Elhan, M.D.†

**Department of Neurosurgery and †Department of Anatomy, Ankara University, Faculty of Medicine, Ankara, Turkey*

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BACKGROUND

There are few studies carried out to reveal lumbar arterial anatomy. The studies of vascular anatomy of the lumbar zone are usually based on the angiographic imaging methods and barium injected radiographic sections of human specimens.

METHODS

Upon the recent breakthroughs in the microscopic anatomic dissections, the vascular structure of this zone is examined in 16 cadavers. Arterial anatomies of the extraforaminal zones of 80 lumbar vertebral objects were studied.

RESULTS

In each segment, lumbar artery, extraforaminal branches of the lumbar artery and the spinal (foraminal) branch were described. The spinal branch is originated from lumbar artery and extends as the dorsal branch. The dorsal branch is divided into 4 branches: ganglionic, transverse, ascending, and descending. Diameters of the lumbar artery, spinal, dorsal, and ganglionic branches were measured at each stage. The mean diameter of the lumbar artery was 2.7 mm, the dorsal branch was 2.0 mm, the foraminal branch was 1.9 mm, and the ganglionic branch was 1.0 mm, respectively.

CONCLUSION

Knowledge of lumbar arterial anatomy is needed for carrying out a successful surgical operation and reducing complications.

KEY WORDS

Lumbar extraforaminal space, lumbar artery, cadaver, anatomy.

Since Mixter and Barr [5] suggested that the intervertebral disk hernia gave rise to the nerve root block, many surgical approaches have been described for treatment. Owing to the recent breakthroughs in the diagnostic technology as well as the increase in the therapy options, it has become vital to have a better understanding of the lumbar vascular anatomy. However, little new information has been gained. In a few studies, the arterial anatomy of this zone was described [1–3,10]. There are some common aspects in the studies of various medical researchers. It is already known that the arterial anatomy of this zone varies during the process extending from the fetal life up to mature life [9]. Studying the arterial anatomy of the extraforaminal zone has revealed that the lumbar artery originates from the abdominal aorta and then extends through the two vertebra corpuses up to the dorsal branch. While moving toward the dorsal branch of the vertebral object, it extends the peripheral branches to the corpus. On its front surface, near intervertebral neural foramen it gives the spinal branch, and then it moves as the dorsal branch toward the back surface of the vertebral object. The dorsal branch is also divided into 4 separate branches: ganglionic, transverse, ascending, and descending. Examining the lumbar arterial anatomy and finding out the relation between this anatomic structure and the lumbosacral bone structure may prove useful information to reduce hemorrhage and complication. This study may act as a guide to the development of more minimal invasive approaches and may be considered as the database for future studies. In this anatomic study, the lumbar arterial structure of the extraforaminal zone was examined.

MATERIALS AND METHODS

In this study, 16 cadavers of ages ranging from 18 to 70 were used. The lumbar arterial anatomies of

Address reprint requests to: Dr. Ayhan Attar, Ankara University, Faculty of Medicine, Ibn-i Sina Hastanesi, Department of Neurosurgery, 06100 Sihhiye, Ankara, Turkey.

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1 Diameters of the Arterial Structures of the Lumbar Intervertebral Neural Foramen and its Vicinities (measurement unit: millimeter)

		Main Branch Diameter		Dorsal Branch Diameter		Spinal Branch Diameter		Ganglionic Branch Diameter	
		Avr	Range	Avr	Range	Avr	Range	Avr	Range
L1	All	2.7	2.0–3.2	1.9	1.0–2.9	1.5	1.0–1.9	0.9	0.3–1.3
	Right	2.4	2.0–3.1	1.8	1.0–2.1	1.5	1.0–1.9	0.8	0.3–1.1
	Left	2.9	2.5–3.2	2.1	1.7–2.9	1.4	1.0–1.6	1.0	0.9–1.3
L2	All	2.2	1.5–2.8	1.7	1.0–2.3	1.4	1.1–1.8	0.9	0.9–1.1
	Right	2.3	2.1–2.8	1.9	1.3–2.3	1.6	1.4–1.8	0.9	0.9–1.0
	Left	2.1	1.5–2.7	1.4	1.0–2.0	1.2	1.1–1.3	1.0	0.9–1.1
L3	All	2.6	2.1–3.2	1.8	1.2–2.6	1.4	0.9–1.9	1.1	0.7–1.7
	Right	2.7	2.4–2.9	1.9	1.4–2.7	1.1	0.9–1.3	1.1	0.8–1.7
	Left	2.5	2.1–3.1	1.7	1.2–2.2	1.6	1.3–1.9	1.0	0.7–1.2
L4	All	2.8	2.3–3.3	2.1	1.5–2.6	1.3	1.1–1.5	1.1	0.8–1.3
	Right	3.0	2.7–3.3	2.3	2.1–2.6	1.3	1.1–1.5	1.1	0.7–1.3
	Left	2.7	2.3–2.9	1.9	1.5–2.4	1.3	1.0–1.5	1.1	1.0–1.3
L5	All	2.9	1.8–3.3	2.2	1.5–2.7	1.5	1.0–1.9	1.1	0.7–1.4
	Right	3.0	2.8–3.3	2.3	1.8–2.6	1.7	1.5–1.9	1.1	0.9–1.4
	Left	2.7	1.8–3.1	2.0	1.5–2.6	1.3	1.0–1.5	1.0	0.7–1.2

these cadavers were examined. Ten of these 16 cadavers were male, while 5 of them were female. None of the subjects had a major deformity such as severe osteoporosis or pathologic fracture. The cadavers were prepared in the neutral-prone position for the study. All the stages of the study were conducted through a detailed dissection using a surgical microscope (Carl Zeiss, OPMI-PRIMO 307953) following the microsurgical principles. It was carried out posterolaterally, including the exploration of T12 and S1. Posteriorly, the soft tissues of each cadaver were removed through a posterolateral approach (cutaneous, subcutaneous, facial, and paraspinal muscles). With the help of laminar Ronguer and Kerrison, spinous processes were extracted. Facet and transverse process were exposed. The lateral part of the transverse process was examined and the intertransverse ligament was recessed. Thus, the extraforaminal arteria was revealed. All the measurements were made by 3 experienced neurosurgeons and 2 experienced anatomists; furthermore, the same anatomic determiners were taken into consideration. All the measurements were made using an electronic digital caliper with a sensitivity degree of 0.1 mm. The following parameters were measured in the study: (1) lumbar artery diameter (LAD), (2) dorsal branch diameter (DBD), (3) foraminal branch diameter (FBD), and (4) ganglionic branch diameter (GBD).

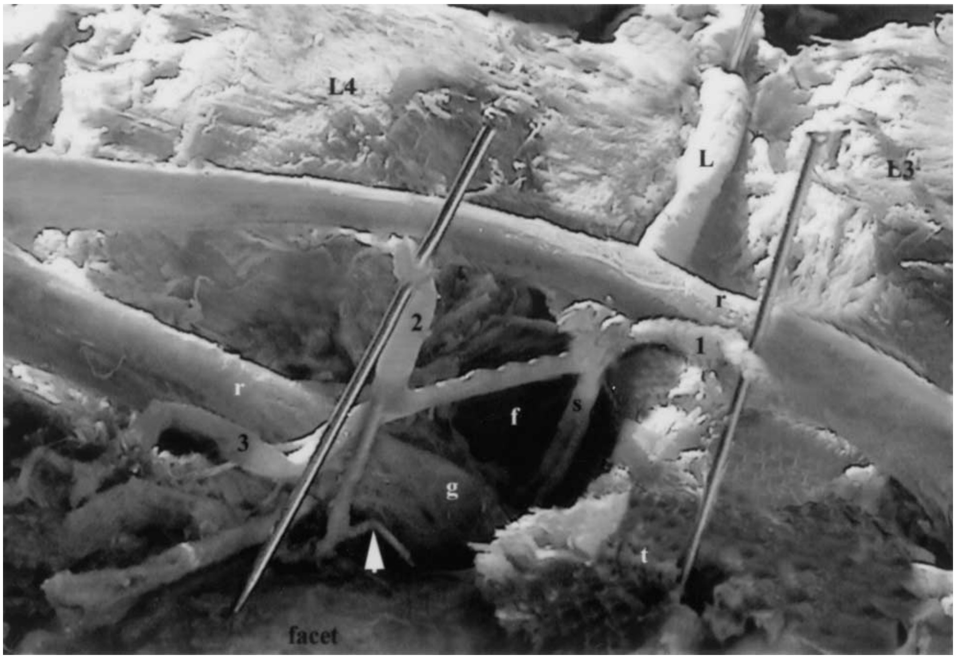
The measurements were made separately for each parameter. The differences between the male and female parameters were evaluated using the Mann Whitney *U* test. The statistically significant difference was shown as $p < 0.05$.

Results

When taking the vertebral dissection of the 16 cadavers as the basis, our study described quantitatively the arterial anatomy of the extraforaminal zone (Tables 1 and 2). The first 4 lumbar arteries

2 Average Arterial Diameters for All Stages (measurement unit: millimeter)

		Main Branch Diameter		Dorsal Branch Diameter		Spinal Branch Diameter		Ganglionic Branch Diameter	
		Avr	Range	Avr	Range	Avr	Range	Avr	Range
L	All	2.7	1.5–3.2	2.0	1.0–2.6	1.4	0.9–1.9	1.0	0.3–1.7
	Right	2.7	2.0–3.3	2.0	1.0–2.6	1.4	0.9–1.9	1.0	0.3–1.7
	Left	2.6	1.5–3.2	1.8	1.0–2.9	1.3	1.0–1.9	1.0	0.7–1.3



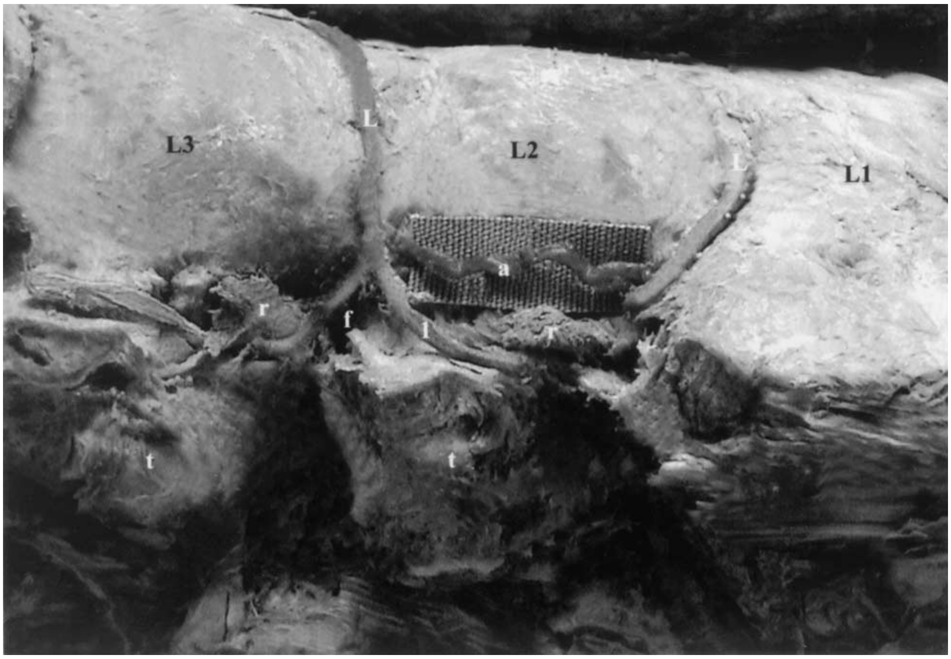
1 Lumbar artery and its branches: (L: Lumbar artery, r: Root, f: Foramen, g: Ganglion, t: Transverse process, s: Spinal branch, 1: Ascendens branch, 2: Descendens branch, 3: Transverse branch, White arrow: ganglionic branch).

originated from the abdominal aorta, while the fifth lumbar artery originated from the iliolumbar artery or median sacral artery. In one cadaver, the fifth lumbar artery of the left side originated from the fourth lumbar artery. Then, the lumbar artery moved through the 2 vertebras toward the dorsal branch, and extended to the perforated branch of the corpus. It extended the spinal branch to the intervertebral neural foramen and moved as the dorsal branch. Before the spinal branch entered the neural foramen, it extends a branch in the direction of the nerve ganglion. The lumbar artery crosses the spinal nerve, and extends as the dorsal branch. The dorsal branch was divided into 4 branches: ganglionic, transverse, ascending, and descending (Figure 1). Transverse, ascending and descending branches extended their feeding branches to the transverse process of the vertebral body and the facet joint and scattered through the paraspinal muscles. The diameters of these arteries were measured separately, and the results are given in Tables 1 and 2. The largest lumbar artery diameter was measured in segment L5, mean 2.9 mm. It was learned that the right lumbar artery was dominant in each lumbar vertebral object. In the extraforaminal zone, several anastomosis were found between lumbar arteries. These anastomotic arteries were between the first and the second lumbar arteries with a rate of 80% (Figure 2). The largest dorsal branch diameter was measured in segment L5, mean 2.2 mm. When evaluating the measurements of the foraminal branch diameters and the ganglionic branch diameters, a significant difference was observed among all the segments. In all these stages of measurements, no statistically significant differences for all the stages was observed between male and female cadavers.

Discussion

There are few studies about the details of the arterial anatomy of the intervertebral neural foramen and its vicinities. The number of such studies has increased over the past 15 years. Angiographic examinations are very important for the evaluation of the arterial anatomy of the lumbar area and the vascular pathologies. Examinations carried out by Gazi Yaşargil and Glenn Pait to discover the vascular anatomy of the lumbar area and to get the angiographic images of vascular pathologies have provided an anatomic orientation for our study [7,11,12]. In this study, the applied microsurgical arterial anatomy of the extraforaminal lumbar zone for surgical process and dissections in the cadavers were described. Furthermore, the relation of the surrounding branches of the lumbar artery and neural foramen with the nerve was revealed.

Better knowledge of the arterial anatomy of the extraforaminal zone may prove helpful for the



2 The anastomatic branch between lumbar arteries: (L: Lumbar artery, a: Anastomatic artery, t: Transverse process, r: Root, f: Foramen).

nerve mobilization in the surgical disk pathologies of this zone. The paraspinal approach [4,6,13,15] for surgical therapy of the extreme lateral disk herniation is a method that is gaining popularity. By this method, the relation between the lumbar arterial branches and the nerve in the extraforaminal zone can be identified. When reaching the extraforaminal zone through surgical dissections performed using the paraspinal approach, the lumbar arterial branches neighboring the nerve can be observed. The dissection of the lumbar arterial branches may facilitate the nerve mobilization.

Rajamaron et al [8] revealed the relation of the lumbar artery and its branches with the nerve of this zone, based on cadaver dissections and intraoperative observations. At the same time, they ensured the anatomic orientation that will help with surgery for extraforaminal disk prolapsus.

In vertebral osteomyelitis spreading through a hematogenous way, several arterial anastomoses were suggested for this zone. Wiley and Trueta [14] suggested an anterolateral extraosseous anastomosis along the inserting disk and in adjacent metaphysial zones in adult and adolescent spines. In their studies, they suggested that these anastomoses gave rise to the vertebral osteomyelitis spreading in a hematogenous way. Ratcliffe [9] suggested that the arteries in the anterolateral part of the vertebral surface inside the intervertebral foramen and in the spinal canal related to each other. In our study, anastomosis between the lumbar arteries in the posteolateral corpus was found. These anastomoses may play a role in the hematogenous spreading of the vertebral osteomyelitis.

Ratcliffe [9] described the lumbar arterial anatomy by angiographic means. As the result of these studies, it was found that one of the lumbar arteries was dominant in each vertebral object. The fifth lumbar artery originated from the median sacral artery and was a small artery when compared to other lumbar arteries. The results obtained in the other studies are in parallel with our study; however, there are some differences as well. In our study, the right lumbar artery diameter was compared with the left lumbar artery diameter. In general, the diameters of the right lumbar arteries were bigger than those of the left lumbar arteries. The fifth lumbar artery originated from the median sacral artery or the iliolumbar artery. In one of the cadavers, the fifth lumbar artery originated from the fourth lumbar artery. The fifth lumbar arteries varied as far as their origination zone is concerned. Unlike the results of Ratcliffe, the fifth lumbar artery diameter was observed to be the biggest. These results were evaluated, taking into consideration the average arterial diameter measurements for all the stages.

In our study, the arterial anatomy of the extraforaminal zone is described. Considering all the data and findings, it can be suggested that more anatomic studies of the lumbar arterial anatomy for a three-dimensional orientation are needed to develop successful surgical technique and reduce the complications.

We wish to extend our deepest gratitude to Prof. Dr. Gazi Yaşargil and Associate Professor Glenn Pait for their invaluable contribution and guidance through this study.

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COMMENTARY

For those surgeons performing extraforaminal lumbar discectomies, Drs. Caglar et al performed an interesting and valuable study of the arterial anatomy of this region. I agree with these authors' contention that knowledge of this region with rich arterial supply will help prevent troublesome bleeding.

In a similar study [1] we also demonstrated an abundance of arterial vessels. In our report, we called attention to an arterial arcade that looped around the ganglion. Part of this arterial loop is seen in Dr. Caglar's article, Figure 1, arrowhead. The loop can be found dorsal to the take-off of the posterior primary ramus of the spinal nerve.

Stewart B. Dunsker, M.D.
Professor Neurosurgery Emeritus
Mayfield Clinic & University of Cincinnati
Cincinnati, Ohio

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