

Evaluation of the Median Sacral Artery in 30 Postmortem Specimens

T. Colak¹, B. Bamac¹, S. Ceylan², S. Kurnaz², U. N. Gundogmus³ and I. Uzun⁴

¹Kocaeli University, Faculty of Medicine, Department of Anatomy, Kocaeli, Turkey
E-mail: tuncaycolak@live.com

²Kocaeli University, Faculty of Medicine, Department of Histology and Embryology, Kocaeli, Turkey

³Istanbul University, Forensic Medicine Enstitüsü, Istanbul, Turkey

⁴Akdeniz University, Faculty of Medicine, Department of Forensic Medicine, Antalya, Turkey

KEYWORDS Artery. Diameter. Median Sacral. Postmortem. Thickness. Tunica Media

ABSTRACT Thirty median sacral arteries (19 males and 11 females) that ranged from 34 to 66 years old (mean age, 50.8 years) postmortem specimens were studied. Sections of formalin-fixed vessels were stained with hematoxylin and eosin. The measurements obtained included tunica media thickness and external diameter of the median sacral artery. The external diameter of the median sacral artery was $1315.06 \pm 291.18 \mu\text{m}$ for males and $1389.31 \pm 243.06 \mu\text{m}$ for females. The tunica media thickness of the median sacral artery was $210.81 \pm 50.43 \mu\text{m}$ for males and $256.35 \pm 31.41 \mu\text{m}$ for females. Females have greater external diameter and tunica media thickness. The difference between the tunica media thickness of the median sacral artery for male and female was statistically different ($P < 0.05$).

INTRODUCTION

The median sacral artery (MSA) is a small artery that arises at the bifurcation of the aorta (Snell 2008). It descends in the midline, anterior to the fourth and fifth lumbar vertebrae, sacrum and coccyx, ending in the coccygeal body. It often gives off a small lumbar artery (arteria lumbalis ima), minute branches of which reach the rectum (Williams 1995). Small and short MSA branches penetrating the posterior wall of the rectum and participating in its vascularization have long been documented (Widmer 1955; Pearl et al. 2014). Anterior to the last lumbar vertebra, the MSA anastomoses with a lumbar branch of the iliolumbar, anterior to the sacrum it anastomoses with the lateral sacral arteries and sends branches into the anterior sacral foramina (Williams 1995). In addition to the lowest lumbar and the right and left lateral sacral arteries, the MSA gives rise to a variable number of branches that pass forward beneath the peritoneum or sigmoid mesocolon to the rectum, where they anastomose with other rectal arteries (Lee et al. 2004). While small in caliber, the MSA continues to exhibit typical aortic features, and it provides in particular paired inter-segmental arteries for the vertebral levels caudal to the so-called aortic bifurcation. Depending on its point of origin and the importance of these vertebral contributions,

the MSA may appear as a small isolated artery or as a trunk providing one or both of the L4 and L5 intersegmental arteries (Pearl et al. 2014). Since it can branch off anterior or posterior radiculomedullary arteries (Merland and Chiras 1981), the MSA is routinely evaluated during diagnostic spinal angiography (Pearl et al. 2014). An iatrogenic median sacral artery is considered to be very rare. Zahrani and Peck (2016) reported a median sacral artery injury following a bone marrow biopsy. Young et al. (2014) reported a median sacral artery iatrogenic injury during percutaneous mechanical disc compression.

This study aimed to examine external diameter and tunica media thickness of the median sacral artery and their relationship to the gender, weight and height of the subjects.

MATERIAL AND METHODS

For the present study, thirty adult (19 males and 11 females) aorta specimens that ranged in age from 34 to 66 years (mean age, 50.8 years) were collected from the Istanbul Forensic Medicine Institute morgue. Thirty MSA were removed from abdominal aorta and used for this study. The specimens were from patients dying from traumatic and accidental causes. Measurements were carried out in Kocaeli University, School of Medicine, Department of Anatomy and Histology.

Tissue Processing, Staining and Examining

The MSA was excised from abdominal aorta at the midpoint of its length. One-half micron thick sections were cut transversely in a plan as nearly as possible perpendicular to the vessel wall. Fixation was performed to the all vessel tissues by ten percent neutral buffered formalin solution (NBF, approximately 4% formaldehyde) for 48 hours and the routine tissue processing steps were treated as follows. Tissues were placed into cassettes and washed in tap water for 8 hours. They were incubated overnight on seventy percent ethyl alcohol solution. Then, they were kept in eighty percent, ninety percent and one hundred percent ethyl alcohol for 2 hours. Tissues were waited in xylene I and II (30 minutes) after gentle shaking in xylene. After they were kept in 1:1 ratio xylene-paraffin mixture for 30 minutes in 57 °C, tissues were allowed to stand overnight in an oven at liquid paraffin. Specimens are embedded in paraffin using embedding rings and orienting tissue to area of interest. Blocks are placed at 4°C for 15 minutes to solidify. The cross-sections were cut from paraffin blocks with a microtome (Leica 2000R) in series of 4µm thick and they were

mounted on glass slides. Slides are allowed to dry in a 37°C oven overnight before staining takes place (Bancroft and Cook 1984). Then hematoxylin and eosin staining was performed on the slides for routine examination. The following procedures were performed for hematoxylin and eosin stain (Fig. 1). Sections were kept in Xylene I and Xylene II for 20 minutes after being waited in an oven for 2 hours at 57 °C and deparaffinization was provided. Specimens were passed through descending series of ethyl alcohol (100% - 90% - 80% - 70%) and they were washed in distilled water for 10 minutes. Sections were then stained with Harris hematoxylin for 5 minutes. They were washed in running tap water for 10 minutes. Sections were dipped in acid alcohol solution, washed in tap water again for 5 minutes and then stained with eosin for 3 minutes. They were washed in running tap water for 10 minutes. Specimens were passed through ascending series of ethyl alcohol (70% - 80% - 90% - 100%). They were cleared in Xylene III and IV for 20 minutes. Sections were mounted under glass coverslips with an aqueous mountant (Entellan- Merk). Preparations were examined under a light microscope (Olympus CX-41RF). All of the sample images in this

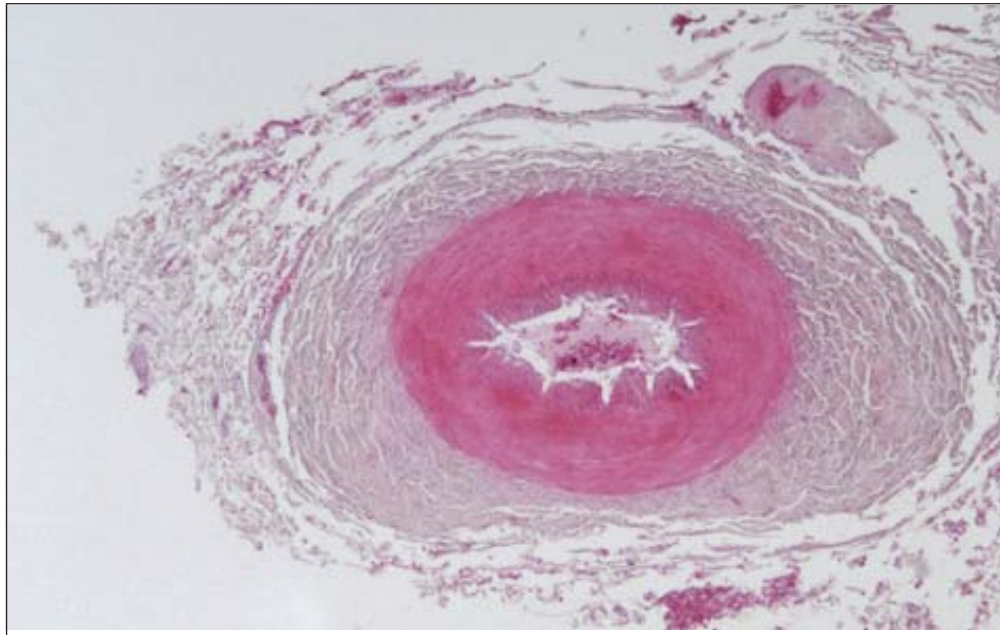


Fig. 1. The median sacral artery stained with hemotoxylin and eosin

study were taken with a camera (Olympus DP26) using the Cell Sense Entry version 2.0 morphometric analysis software (Empix Imaging Co., Mississauga, Canada). The thickness of the tunica media and external diameter of the median sacral artery were measured using this program (Figs. 2 and 3).

Statistical Methods

The means, standard deviations, and ninety-five percent confidence intervals were calculated for the data. The independent sample t-test was used to compare the variables between males and females. The significance level was set at 0.05.

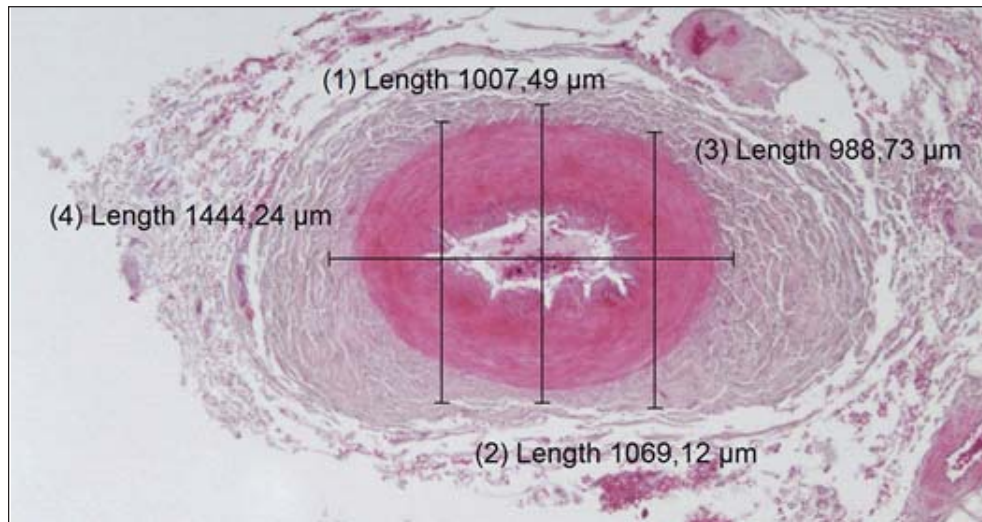


Fig. 2. The external diameter of the median sacral artery

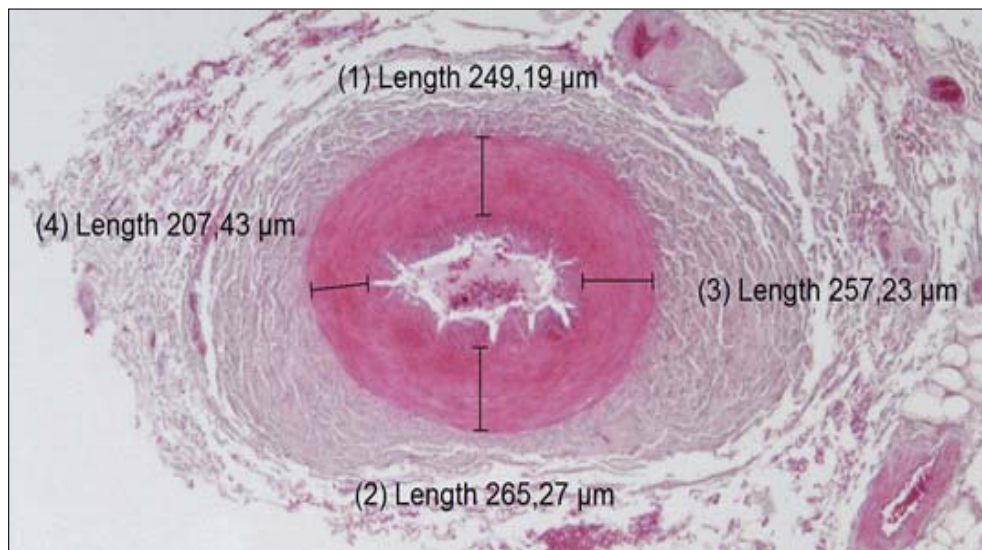


Fig. 3. The tunica media thickness of the median sacral artery

Pearson correlation coefficient was used to analyze the correlation between the variables.

This study was conducted according to the guidelines of the Declaration of Helsinki, and was approved by the ethics committee of the faculty.

RESULTS

Males were found to be significantly higher ($P = 0.001$) compared with females. There were no significant differences between males and females for weight ($P=0.545$). The mean external diameter and the mean tunica media thickness of all 30 MSA were $1345.86 \pm 268.77 \mu\text{m}$ and $228.45 \pm 48.62 \mu\text{m}$, respectively. The mean MSA external diameter in the males and females were $1315.06 \pm 291.18 \mu\text{m}$ and $1389.31 \pm 243.06 \mu\text{m}$, respectively ($p < 0.05$). The mean tunica media thickness of MSA in the males and females were $210.81 \pm 50.43 \mu\text{m}$ and $256.35 \pm 31.41 \mu\text{m}$, respectively. There is statistical difference in tunica media thickness of MSA between males and females ($p = 0.012$) (Table 1). The tunica media thickness was correlated positively with diameter both, in males and females, ($p = 0.002$ and $p = 0.004$ respectively). Height and weight of females were correlated positively with each other ($P=0.004$

and $P=0.046$ respectively). There were no correlations between tunica media thickness of MSA and height both in male and females. There were no correlations between tunica media thickness of MSA and weight both in male and females (Table 2).

DISCUSSION

It is commonly accepted that the MSA anatomy is important for prevention of intra-operative bleeding. Samudrala et al. (1999) underscored that the median sacral artery (MSA) was one of the most vulnerable critical structures at risk during anterior lumbar surgery. It must be identified and controlled when the anterior L5-S1 disc space is approached (Tribus and Belanger 2001). Anterior approaches to the lumbar spine have gained popularity in treating a multitude of pathologies, including deformity, degenerative disease, trauma, infection, and tumor. The most commonly accessed disc spaces with the anterior approach are those at L5-S1 and L4-5. The L5-S1 disc space is posterior to the MSA, typically between the left common iliac vein and the right common iliac artery. Proper exposure at this level requires careful retraction of these vessels and typically ligation of the MSA (Ropper et al. 2013).

Table 1: Overall characteristics of the postmortem specimens

Characteristics	Total (Mean $\pm$ SD) n=30	Female (Mean $\pm$ SD) n=11	Male (Mean $\pm$ SD) n=19	p
Height(cm)	165.73 $\pm$ 9.15	158.90 $\pm$ 10.38	169.68 $\pm$ 5.48	0.001
Weight(kg)	71.76 $\pm$ 13.73	69.72 $\pm$ 14.99	72.94 $\pm$ 13.22	0.545
External diameter of MSA(μm)	1345.86 $\pm$ 268.77	1389.31 $\pm$ 243.06	1315.06 $\pm$ 291.18	0.482
Tunica media thickness of MSA(μm)	228.45 $\pm$ 48.62	256.35 $\pm$ 31.41	210.81 $\pm$ 50.43	0.012

*MSA indicates median sacral artery.

Significant P values are shown in bold. ($p < 0.05$)

Table 2: Correlation between characteristics of male and female

	Height (cm)		Weight (kg)		External diameter of MSA (μm)	
	Female	Male	Female	Male	Female	Male
Weight (kg)	0.046	0.413				
Height (cm)	0.004	0.743	0.611	0.594		
Tunica media thickness of MSA(μm)	0.674	0.533	0.648	0.403	0.004	0.002

*MSA indicates median sacral artery.

Significant P values are shown in bold. ($p < 0.05$)

While many researchers detected position of the MSA (Wieslander et al. 2006; Flynn et al. 2005; Guvencer et al. 2009; Sae-Jung et al. 2015), this study's researchers found no detailed report on its histological features. In this study the mean MSA diameter in the males and females were $1315.06 \pm 291.18 \mu\text{m}$ and $1389.31 \pm 243.06 \mu\text{m}$, respectively. Two studies assessed the width of the MSA. In 2001, Tribus and Balanger reviewed the vascular anatomy anterior to the L5-S1 disk space and its potential effect on the performance of a L5-S1 lumbar laminectomy from an anterior approach. They found that the MSA varied greatly in both its diameter and location in relation to the midline. They observed that the middle sacral artery was present in one hundred percent of the specimens, averaging 2.5mm (1.5-5mm) in width. They made metric caliper measurements. Wieslander et al. (2006) performed dissections of the female presacral space in 52 unembalmed female cadavers. In their study, a MSA was present in one hundred percent of cadavers and the average width of the vessel was 2mm (1-4 mm). They measured distances using calipers and plastic ruler. In Guvencer et al.'s (2009) study, the diameters of the MSA were measured as 2.8 ± 0.5 , 2.6 ± 0.4 , 2.6 ± 0.4 , 2.5 ± 0.4 , 2.4 ± 0.4 , and 2.3 ± 0.3 mm, using a caliper, at the levels of L5-S1, S1-2, S2-3, S3-4, S4-5, and S5-coccyx, respectively. Because the present study is the first report to provide a detailed histological description of the MSA, there are no articles measuring external diameter and tunica media thickness of the MSA, and hence, the researchers could not compare the results with previous studies.

In the present study there were statistical differences in tunica media thickness of MSA between males and females. Females have thicker tunica media than males. In other words, males have medial thinning. The researchers have no certain explanation for this result. Nevertheless, one possible explanation of this finding is that some of the males may have alterations in the structural properties of the MSA wall. In fact, the aorta undergoes significant changes with normal aging and there are many studies that investigate hypertension and atherosclerosis-induced changes (Virmani et al. 1991). The researchers can admit that age related changes might occur in the MSA, mostly in males in this study.

Van Dijk et al. (2010) performed a systematic analysis in 260 consecutive peri-renal aortic patches collected during organ transplantation.

They observed significant intimal thickening and medial thinning with advancing age. Their data suggest that smoking was associated with increased medial thinning in the age group of over 60 years and medial thickness was not influenced by gender or by a history of hypertension. Kaupila et al. (1997) assessed the prevalence of arterial diseases in the arteries that supply the lumbar spine and their relation to other cardiovascular diseases, as well as to low back pain. Five pairs of the lumbar arteries and the MSA were evaluated from 140 postmortem aortograms. Their study showed that the lumbar and MSA frequently become obliterated by atheromatous lesions during adult life, and that obliteration of these arteries is more common in subjects with a history of chronic back pain than in those without. Compared with the rest of the aorta, this part of the aorta, especially at the orifices of branching arteries, often shows the earliest and most pronounced involvement of atherosclerosis 2-5.

Since the specimens were from patients dying from traumatic and accidental causes, the researchers do not know whether they were smokers or hypertensive. Therefore, it is hard to make interpretations about this condition.

CONCLUSION

This histomorphometric study has shown significant differences for the tunica media thickness of the MSA between males and females.

LIMITATIONS

1. Although the cadaver specimens used were unembalmed, it is possible that post-mortem vasoconstriction results in underestimation of the measurements of the vessels.
2. The number of specimens examined in the present study is quite small. Therefore, further studies using a larger sample size are required.
3. There is relatively little research involving MSA and therefore, comparison of the data with previous data is difficult.

REFERENCES

- Bancroft JD, Cook HC 1984. *Manual of Histological Techniques*. 1st Edition. New York: Churchill Livingstone.
- Flynn MK, Romero AA, Amundsen CL, Weidner AC 2005. Vascular anatomy of the presacral space: A

- fresh tissue cadaver dissection. *Am J Obstet Gynecol*, 192: 1501-1505.
- Guvencer M, Dalbayrak S, Tayefi H, Tetik S, Yilmaz M, Erginoğlu U, Baskan Ö, Güran S, Naderi S 2009. Surgical anatomy of the presacral area. *Surg Radiol Anat*, 31(4): 251-257.
- Kauppila LI 1997. Prevalence of stenotic changes in arteries supplying the lumbar spine: A postmortem angiographic study on 140 subjects. *Ann Rheum Dis*, 56: 591-595.
- Kim YU, Chae EY, Lee JH, Lee CH, Kim YK 2014. Median sacral artery injury during percutaneous mechanical disc compresion using Dekompressor®. *Korean J Anesthesiol*, 67(Suppl): 60-61.
- Lee JH, Lee KH, Chung WS, Hur J, Won JY, Lee DY 2004. Transcatheter embolization of the middle sacral artery: Collateral feeder in recurrent rectal bleeding. *AJR Am J Roentgenol*, 182(4): 1055-1057.
- Merland JJ, Chiras J 1981. *Arteriography of the Pelvis: Diagnostic and Therapeutic Procedures*. New York: Springer-Verlag.
- Pearl MS, Gest TR, Gailloud P 2014. Superior rectal artery origin from the median sacral artery-angiographic appearance, developmental anatomy, and clinical implications. *Clin Anat*, 27(6): 900-905.
- Ropper AE, Nalbach SV, Groff MW 2013 Vascular complications from anterior lumbar spine surgery. *World Neurosurg*, 79(5-6): 666-668.
- Sae-Jung S, Khamanarong K, Woraputtaporn W, Amarttayakong P 2015. Awareness of the median sacral artery during lumbosacral spinal surgery: An anatomic cadaveric study of its relationship to the lumbosacral spine. *Eur Spine J*, 24(11): 2520-2524.
- Samudrala S, Khoo LT, Rhim SC, Fessler RG 1999. Complications during anterior surgery of the lumbar spine: An anatomically based study and review. *Neurosurg Focus*, 7: E9.
- Snell, RS (Ed.) 2008. *Clinical Anatomy by Regions*. 8th Edition. USA: Lippincott Williams and Wilkins.
- Tribus CB, Belanger T 2001. The vascular anatomy anterior to the L5-S1 disk space. *Spine*, 26(11): 1205-1208.
- Van Dijk RA, Virmani R, Von der Thüsen JH, Schaa-pherder AF, Lindeman JHN 2010. The natural history of aortic atherosclerosis: A systematic histopathological evaluation of the peri-renal region. *Atherosclerosis*, 210(1): 100-106.
- Virmani R, Avolio AP, Mergner WJ, Robinowitz M, Herderick EE, Cornhill JF, Guo SY, Liu TH, Ou DY, O'Rourke M 1991. Effect of aging on aortic morphology in populations with high and low prevalence of hypertension and atherosclerosis: Comparison between occidental and Chinese communities. *Am J Pathol*, 139(5): 1119-1129.
- Widmer O 1955. Die Rectalarterien des Menschen. *Anat Embryol*, 118: 398-416.
- Wieslander CK, Rahn DD, McIntire DD, Marinis SI, Wai CY, Schaffer JI, Corton MM 2006. Vascular anatomy of the presacral space in unembalmed female cadavers. *Am J Obstet Gynecol*, 195(6): 1736-1741.
- Williams PL 1995. *Gray's Anatomy. Cardiovascular System*, 1558. 38th Edition. USA: Churchill Livingstone.
- Zahrani AI Y, Peck D 2016 Median sacral artery injury following a bone marrow biopsy successfully treated with selective trans-arterial embolization: A case report. *J Med Case Rep*, 10(1): 42.

Paper received for publication on January 2016
Paper accepted for publication on April 2016