

Variability of the superior and inferior gluteal arteries in cadaveric study

Abstract

Background: The anatomy of the gluteal arteries is a topic of great importance in clinical practice, as knowledge of their variant structure holds significant value for accurate examination, diagnosis, and treatment of various conditions.

Objective: In this article, the main variations in the anatomy of the gluteal arteries are explored. Understanding these variations will enable medical professionals to perform more precise diagnoses and select the most effective treatment methods.

Methods: For the current study with the help of anatomical dissection method, 34 cadavers of people aged over 50 years (19 females and 15 males) were investigated. 68 preparations of pelvic arteries in total were studied. In each case the internal iliac artery and its branches, including gluteal arteries were investigated.

Results/Conclusion: The individual variability of the gluteal vessels was shown. The inferior gluteal artery has greater variability in comparison with the superior one. Some slight asymmetry is characteristic for gluteal arteries, both in male and female. The anatomical correlation of gluteal arteries with some other vessels of pelvis have been revealed.

Keywords: gluteal artery, variability, asymmetry, correlation, topography

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Introduction

The superior and inferior gluteal arteries, branches of the internal iliac artery, exhibit remarkable variations in their anatomical patterns. Their origins, courses, relationships with neighboring structures, and termination points can differ significantly among individuals.¹⁻³ These variants, although not a cause for alarm, present challenges in clinical practice, surgical procedures, and radiological interpretations. Hence, a comprehensive exploration of these variant anatomical patterns is imperative to enhance medical expertise and ensure patient care efficacy.⁴ The variant anatomy of the superior and inferior gluteal arteries is a topic of great significance in clinical medicine.⁵ These arteries, which supply the gluteal region, exhibit important anatomical variations that have substantial implications for surgical procedures, radiological interventions, and overall patient care. Understanding these variations is essential for accurate diagnosis, treatment planning, and minimizing potential complications. The anatomy of both, superior and inferior, gluteal arteries typically includes variations in their origin, course, branching pattern, and termination. These variations can affect the blood supply to the gluteal muscles, skin, and surrounding structures. In the clinical realm, accurate knowledge of the variant anatomy of the superior and inferior gluteal arteries is of paramount importance. Surgeons performing procedures in the gluteal region, such as reconstructive surgeries, flaps, or gluteal artery perforator-based procedures, need to navigate these intricate vascular pathways with precision.^{6,7} Additionally, interventional radiologists rely on this knowledge to ensure safe and effective transcatheter embolization or angiographic procedures. The correct identification and understanding of these variants minimize procedural complications and optimize patient outcomes.

The literature describes various variations of the origination of superior and inferior gluteal arteries.¹⁻⁹ After analyzing the literature data, we can conclude that there is no consensus on the arising of these vessels. There is a significant lack of data regarding the variable anatomy of the gluteal arteries. In clinical medicine, the variant

anatomy of the upper and lower gluteal arteries plays a critical role in the successful outcome of various procedures, including buttock augmentation, gluteal muscle flaps, reconstructive surgery for pressure sores, and management of traumatic injuries. Accurate identification and understanding of these variations are crucial to avoid complications such as excessive bleeding, ischemia, necrosis, and nerve damage.⁶ Traumatic pelvic injury often results in massive bleeding from the gluteal arteries, which are the biggest branches of the internal iliac artery and a surgeon who knows the details of the structure of these vessels can prevent undesirable consequences of this pathological condition.^{10,11}

The primary aim of our research is to comprehensively document the variant anatomy of the superior and inferior gluteal arteries. By conducting a systematic review of existing literature, combined with our observations and findings, we aim to consolidate the current understanding of these arterial variants. Our research endeavors to provide a valuable resource for medical professionals, aiding in accurate diagnosis, treatment planning, and surgical interventions in the gluteal region. Through this study, we ultimately strive to contribute to advancements in clinical practice and promote improved patient care.

Materials and methods

The study was performed on the basis of the Department of Normal Anatomy of Grodno Medical University in the period from August 2022 to November 2023. A carefully selected group of cadavers, procured through established anatomical donation programs, formed the foundation of our research.

34 cadavers of individuals, ages 50 to 75 years, who died because of injuries and had no history of diseases of the cardiovascular system were selected for the current study. Among them, 19 were females and 15 males. In total 68 specimens of the pelvic arteries (33 right and 35 left) were studied.

All the cadavers were fixed by 10% formalin and no other chemicals were used for embalming. The dissection process commenced with a thorough external examination, where we identified landmarks and studied the surface anatomy of the pelvic region. Following this, precise incisions and dissections were carried out to expose the underlying fascia, allowing for the isolation and examination of the gluteal arteries while preserving their anatomical integrity. We methodically traced the trajectory of the gluteal arteries, documenting their origin, branching patterns, and relationships with neighboring structures. The following anatomical parameters were described: origin of the arteries, their length and external diameter (the diameter was measured in the site of its origin). All parameters were studied depending on age and gender.

The obtained data were statistically processed using the “Statistica 10.0” PC soft program. The statistical package “Descriptive statistics” was used to obtain statistical data (mean value – M, mean quadratic deviation – σ , etc.). The Spearman test was used to study the correlation relationships of morphometric parameters of the gluteal arteries with other pelvic arteries. The coefficient $p < 0.05$ was taken as the minimum reliability of the differences in the compared parameters.

In order to identify eligible articles for our review, an extensive search through the basic electronic databases was accomplished.

Ethical statement is not applicable for this study.

Results

During the dissection, the following findings were observed.

The superior gluteal artery is not highly variable. In most cases, the superior gluteal artery is a continuation of the posterior division of the internal iliac artery. It was seen in 72.1% of cases. In 26.5% it is a branch of the internal iliac proper and only in 1.4% we have found a trifurcation – arising of superior and inferior gluteal and internal pudendal arteries by one trunk.

Table 2 The dependence of the superior gluteal artery on gender

Source of the superior gluteal artery	Males				Females			
	Right absolute values	%	Left absolute values	%	Right absolute values	%	Left absolute values	%
Internal iliac artery	1	7.7*	3	17.6	9	45.0*	5	27.8
Posterior division of internal iliac artery	12	92.3*	14	82.4	11	55.0*	12	66.7
Common trunk for the inferior gluteal and internal pudendal arteries	–	–	–	–	–	–	1	5.5

Note: * – the significance of the difference is $p < 0.05$.

As per Table 2, the posterior trunk of the internal iliac artery is the source of the superior gluteal artery on the right more often in males, and the internal iliac artery more often was noted in females.

We investigated and determined the correlation relationships of the anatomical parameters of the superior gluteal artery.

As the result, we got a significantly high ($r > 0.7$) correlation of the site of arising of the superior gluteal artery from the diameter, and length of the posterior division of the internal iliac artery ($p < 0.00001$). The lower correlation ($0.4 < r < 0.7$) of the site of the beginning of the gluteal artery with the diameter of the anterior division ($p < 0.00001$), the diameter of the common and external iliac arteries ($p < 0.001$) is observed. The length of the superior gluteal artery correlates with gender: in males, the artery is shorter – 2.16 ± 1.20 cm than in females – 3.18 ± 2.15 cm ($r = 0.4$; $p < 0.001$).

There is a dependence of the origination of the superior gluteal artery on gender.

In our study, the superior gluteal artery, which starts from the common trunk for the inferior gluteal and internal pudendal arteries, was found in one specimen only, in a female cadaver (2.7%). The origination of the superior gluteal artery from the posterior division of the internal iliac artery was noted more often (in 26 specimens, in 86.7%), in male than in female (23 specimens, 60.5%) ($p < 0.05$). However, the arising of the gluteal artery directly from the internal iliac artery in females was found in 14 specimens (36.8%), while in males, only in 4 specimens (13.3%) ($p < 0.05$).

We have not found any information on asymmetry of the superior gluteal artery in the literature, so we decided to study this problem (Table 1).

Table 1 Asymmetry of the superior gluteal artery

Source of the superior gluteal artery	Left		Right	
	absolute values	%	absolute values	%
Internal iliac artery	8	22,8	10	33,3
Posterior division of internal iliac artery	26	74,3	23	
Common trunk for the inferior gluteal and internal pudendal arteries	1	2,9	–	–

As per Table 1, the arising of the superior gluteal artery from the internal iliac artery was found slightly more often on the right, and its origin from the one trunk for the inferior gluteal and internal pudendal arteries was found on the left only.

The results of the study showed the gender-specific characteristics of the beginning of the superior gluteal artery (Table 2).

According to our study, the diameter of the superior gluteal artery is correlated with the diameter of the common iliac artery ($r = 0.41$; $p < 0.001$), the diameter of the external iliac artery ($r = 0.64$; $p < 0.00001$) and the diameter of the internal iliac artery ($r = 0.42$; $p < 0.001$). In addition, the superior gluteal artery correlates with some small vessels (iliolumbar, lateral sacral, inferior epigastric, vesical arteries). As a result, knowing the morphological features of the superior gluteal artery, makes it possible to indirectly judge the morphology of these vessels.

The inferior gluteal artery is more variable compared to the superior gluteal artery. During the current study we have noted the inferior gluteal artery arising from the internal iliac artery in 10.3%, by the one trunk with the internal pudendal artery in 51.6%. This variant was found in the most of cases. Inferior gluteal artery is a

branch of the anterior division of internal iliac artery in 30.9%, in 1.5% it started by the one trunk with the superior gluteal.

In addition, we have described several variations that have not been found in the literature: beginning of the inferior gluteal artery from the posterior division of the internal iliac artery (in 2.9%), by the one trunk with the obturator artery (in 1.4%) and from the «middle» trunk of the internal iliac artery (in 1.4%). In the last variation the internal iliac artery is divided into three trunks: the anterior – «classical», the posterior one, from which the superior gluteal and ilio-lumbar arteries

arise, and the «middle» trunk, from which gives off the inferior gluteal and lateral sacral arteries.

The current study revealed a slight asymmetry of the inferior gluteal artery. Thus, some variations (beginning from the superior gluteal artery and by the one trunk with the obturator artery) were noted only on the left, while the arising of the gluteal artery from the «middle» trunk was found only on the right.

The gender-specific characteristic of the inferior gluteal artery is shown in Table 3.

Table 3 Gender-specific characteristic of the inferior gluteal artery

Source of the inferior gluteal artery	Males		Females		Females		Right	
	Right absolute values	%	Left absolute values	%	absolute values	%	absolute values	%
Internal iliac artery	–	–	2	11,8	3	15,0	2	11,1
One trunk with the superior gluteal artery	–	–	–	–	–	–	1	5,5
Common trunk for the internal pudendal arteries	6	46,2	10	58,8	12	60,0	7	38,9
Anterior division of the internal iliac artery	7	53,8*	5	29,4	3	15,0*	6	33,3
Posterior division of the internal iliac artery	–	–	–	–	1	5,0	1	5,0
«Middle» trunk of the internal iliac artery	–	–	–	–	1	5,0	–	–
One trunk with the obturator artery	–	–	–	–	–	–	1	5,0

Note: * – the significance of the difference is $p < 0.05$.

Table 3 shows that the internal iliac artery gives off the inferior gluteal artery more often in female specimens than in male ones.

The inferior gluteal artery, like the superior gluteal one, correlates with other vessels of the pelvis, which has high clinical value during the diagnosis of vascular pathology. The length of the inferior gluteal artery is in positive correlation with the diameter of the common iliac artery ($r=0.34$; $p < 0.01$), the diameter of the posterior division of the internal iliac ($r=0.33$; $p < 0.01$), the length of the posterior division ($r=0.37$; $p < 0.01$), the diameter of the uterine artery ($r=0.5$; $p < 0.00001$). In addition, a high correlation is observed between the length and diameter of the inferior gluteal artery ($r=0.70$; $p < 0.0000001$), as well as between the lengths of the gluteal and internal pudendal arteries ($r=0.83$; $p < 0.0000001$). The arising of inferior gluteal and internal pudendal artery is interdependent ($r=0.80$; $p < 0.0000001$).

Discussion

The superior gluteal artery (a. glutea superior) has various variants of its arising.

As a rule, the superior gluteal artery is a direct continuation of the posterior division of the internal iliac artery.^{3,12-14} In our study, the origination of the superior gluteal artery from the posterior trunk of the internal iliac artery was also observed in most cases (72.1%). Incidentally, it can start with a common trunk with other arteries.^{2,3,12} According to some authors the superior gluteal artery can start by the one trunk with the inferior gluteal artery (in 16-22%), by one trunk with internal pudendal artery (0.5-10%) or by common trunk with both inferior gluteal and internal pudendal artery (1-4%).^{3,13-15} Our study showed a more significant variability of the superior gluteal artery compared to studies by other authors.

As already mentioned above, there is a dependence of the origination of the superior gluteal artery on gender. According to some studies,^{3,5,14,15} the superior gluteal artery beginning from the posterior division of the internal iliac artery is more common (87%) in females than in males (81%). However, our research has shown a completely different picture: the origination of the superior gluteal artery from the posterior division of the internal iliac artery was noted more often (in 86.7%) in male than in female (60.5%) cadavers ($p < 0.05$).

Since we did not find information on the symmetry of the anatomy of the gluteal arteries in the available literature sources, we conducted a study in this direction. The results of the study showed that the left gluteal artery is more variable compared to the right.

When studying the human body, it is crucial to recognize and appreciate the variations that exists between individuals. Particularly, understanding the gender-specific differences in the structure of gluteal arteries holds great significance in various medical fields. Firstly, it is essential to acknowledge that anatomical differences between male and female pelvises extend beyond reproductive organs. The vascular system, including the gluteal arteries, can exhibit divergence due to underlying physiological dissimilarities. Developing a comprehensive understanding of these variances allows healthcare professionals to tailor their diagnostic and treatment approaches accordingly.^{10,11,13}

In male anatomy, the gluteal artery tends to form a robust network, providing a substantial blood supply to the muscles and other structures in the gluteal region. The intricate intertwining of the vessels modulates perfusion and ensures efficient oxygenation and nutrient delivery to these tissues. Recognizing these characteristics is crucial, as it can help surgeons plan and execute procedures with greater precision and minimize the risk of complications.

Conversely, in female anatomy, the gluteal artery network might display certain variations. In cases where the pelvis undergoes changes during pregnancy, childbirth, or hormonal shifts, the gluteal arteries can become subject to altered anatomical pathways or even temporary modifications. This knowledge is particularly vital in obstetrics and gynecology, as it aids in comprehending potential complications or variations encountered during diagnostic imaging, interventional procedures, or surgeries in the gluteal region.

Moreover, gender-specific differences in the structure of gluteal arteries also contribute to optimizing patient care during reconstructive or cosmetic surgeries. Understanding how these arteries differ between sexes enables plastic surgeons to better plan and execute procedures such as gluteal augmentation or liposuction, ensuring optimal results while minimizing potential risks.^{7,16}

Despite the great importance of gender differences, in previous studies by other authors, there is scant data on the gender-specific characteristics of the anatomy of the gluteal arteries. Our study showed gender-specific differences in the anatomy of the gluteal arteries. It has been shown that in females, the gluteal arteries are more variable compared to males.

It is important in clinical medicine to make an accurate diagnosis of vascular pathology. Quite often, for several reasons, a radiologist does not always manage to get a clear picture during angiography, as a result of which the examination of a vessel is problematic.^{16,17} In these cases, it is recommended to use indirect diagnostic methods.

In connection with the above, it is of great clinical importance to know the correlation of the anatomical parameters of the gluteal arteries both among themselves and with other arteries of the pelvic cavity.

The superior gluteal artery, passing through the pelvic cavity, is firmly fixed to its wall by the lateral sacral and iliac branches extending from the artery. Then the superior gluteal artery passes above the piriformis muscle through the suprapiriform foramen, exits the pelvic cavity into the gluteal region. In most cases, the artery lies here directly on the sciatic notch above the sciatic nerve and is accompanied by the same named (one or, more often, several) veins. Just after leaving the pelvic cavity, it can have a scattering type of branching (in 62.5%), magistral (16%) or intermedial (in 21.5%). This should be considered when performing surgical interventions, since with a scattering type of branching of the superior gluteal artery, it is less available for ligation from the gluteal region in case of injury or aneurysm of this vessel. This is confirmed by several studies.^{1,3,13,18,19}

The inferior gluteal artery is more variable compared to the superior gluteal artery. We have found in literature that the artery can arise from internal iliac artery (from 21% to 33%), from superior gluteal artery (up to 7.5%), from the internal pudendal artery (up to 14%), by the one trunk with the superior gluteal artery (in 16-20%), by the one trunk with the internal pudendal artery (in 43-62%), by the common trunk with the superior gluteal and internal pudendal artery (in 1-4%).^{2,3,4,19}

In cadavers from our study the most common source for the inferior gluteal artery is common trunk with the internal pudendal artery (51.6%). It is similar to the literature data.

The common trunk for the inferior gluteal and internal pudendal arteries is not always divided in the pelvis. Results of our study show that the extrapelvic division of the common trunk was found in 16 specimens (in 45.7% of cases). This variant was more often observed in females (52.6%) than in males (37.5%). According to some authors, the inferior gluteal artery was absent in 1-2% of cases.^{3,12,20}

The inferior gluteal artery passes through the infrapiriform foramen anteriorly of the sacral plexus trunks lying on the piriformis muscle. On its way, the artery passes between III and IV, less often between II and III sacral nerves or between the roots of the sciatic nerve. Then, together with the vv. iliaci interni, the inferior gluteal artery lies in the infrapiriform foramen between the internal pudendal artery medially and the sciatic nerve laterally.^{1,3,19,21} In the gluteal region the inferior gluteal artery splits into numerous muscular branches (it has a scattering type of branching in 100% of cases).

The study is subject to several limitations including challenges in accessing an adequate sample size due to difficulties in material collection. The scarcity of postmortem materials hinders the availability of suitable specimens necessary for thorough investigation. Consequently, this shortage restricts the scope of the study and limits the analysis to a smaller sample size. Despite these limitations, efforts have been made to utilize the available resources and draw meaningful conclusions from the obtained data.

Conclusion

In conclusion, the study of variant anatomy of gluteal arteries highlights the importance of recognizing individual anatomical differences.

The variability of the gluteal vessels is shown. The superior gluteal artery is less variable than the inferior gluteal. The gluteal arteries are characterized by asymmetry in both male and female, which may be since both vessels are parietal branches of the iliac artery, which are fixed to a certain extent to the walls of the pelvis.

Reliable correlation of the gluteal arteries with some other pelvic vessels have been identified, which can help specialists in the diagnosis of both vascular and organic pathology. The received results of the study can be used in surgical practice.

Further research and awareness in this field are necessary to advance medical knowledge and improve patient care. By embracing the understanding of variant anatomy in gluteal arteries, healthcare professionals can tailor their approaches to each patient's unique anatomical characteristics, maximizing the effectiveness and safety of treatments.

Acknowledgments

None.

Conflicts of interests

None.

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