A STUDY OF THE COURSE, BRANCHING PATTERN AND DIMENSIONS OF THE SUPERIOR AND INFERIOR GLUTEAL ARTERIES

Anatomy

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ABSTRACT

Background: There is a lacuna of information regarding the dimensions of the gluteal arteries. **Aim:** The present study is to present a detailed account of the pattern of blood supply dimensions of the superior and inferior gluteal arteries. **Methods:** 62 pelvic halves embalmed with a modified Larssen solution **Results & Conclusion:** Variations were observed in the origin, course, distribution, and dimensions of superior gluteal (6.45%) and inferior gluteal arteries (9.68%) which are significant, considering the importance of management of clinical conditions associated with the gluteal region like gluteal claudication, neuralgia, and harvesting of perforator flaps.

KEYWORDS

Superior and Inferior gluteal arteries, Dimensions, Gluteal claudication, Perforator flaps

Introduction:

While the hemodynamics of certain arteries are well documented[1] none exist of the superior and inferior gluteal arteries supplying the gluteal region[2]. The superior gluteal (SG) originated from the posterior division of the internal iliac artery (IIA) and enters the gluteal region from the greater sciatic foramen above the piriformis. The inferior gluteal (IG), a branch of the anterior division of IIA, traverses the lower part of the greater sciatic foramen and exits the pelvic cavity to supply the muscles of the gluteal region. Occlusion of the SG and IG arteries or their branches is known to cause gluteal claudication and in some cases even necrosis of the gluteal region[3] and intractable sciatic neuralgia[4]. Hence invasive image-guided revascularization procedures are increasingly used in the treatment of such conditions. Knowledge of the pattern of blood supply through the SG and IG is particularly relevant for the creation of perforator flaps from the gluteal region for breast reconstruction[5] and repair of the perineum[6]. Therefore, characterization of the origin, course, dimensions, and branches of the SG and IG will lead to better preoperative investigation and diagnosis and consequently increased the success of minimally invasive surgery.

Materials and Methods:

The SG and IG arteries and its branches were dissected in 31 adult cadavers (62 pelvic halves) of which 15 were male and 16 were female (34-75 years) in the Department of Anatomy NRIIMS, Visakhapatnam during the year 2018-2020. All the cadavers were embalmed with a modified Larssen solution. The lengths of individual arteries were measured using a Fowler 54-101-175 Poly-Cal Digital Calliper (resolution: 0.01 mm accuracy: 0.02 mm). The external diameters of these arteries were measured using a Mitutoyo 753-1966 Digimatic Digital (resolution: 0.005 mm accuracy: 0.01 mm). All statistical analyses were carried out using SPSS software, version 11.0 (SPSS Inc.; Chicago, Ill). The values are presented as mean $\pm$ SD (standard deviation). The Chi-squared test was used to analyse differences in gender and side, while continuous data were compared using the Student t-test. A p-value of ≤ 0.05 was considered significant.

Observations:

A total of 31 cadavers of which 15 were male and 16 were female were studied. All dimensions of the SG and IG and their branches are presented as the mean $\pm$ SD and range. An artery with a dimension of 1 SD or more below the mean value was operationally defined to be smaller than normal. Similarly, a vessel with a dimension of 1 SD or more above the mean value was considered to be larger than normal.

There were no variations in 96.77% in the origin, course, or distribution of the SG. However, in one (1.61%) male specimen on the

left side and in one (1.61%) female specimen on the right side, the SG, IG and the lateral sacral (LS) artery originated as a common trunk from the posterior division of the internal iliac artery. In addition, in one (1.61%) female cadaver the obturator artery (OA) originated from the SG (Table 2) (Figure 1). The mean length of the SG was 7.07 ± 0.18 cm on the left side and 7.04 ± 0.11 cm on the right side. The mean external diameter of SG was 1.26 ± 0.22 mm on the left side and 1.28 ± 0.21 mm on the right side (Table 1). Since the mean external diameters of the SG displayed a wide range, further analysis of the external diameters of the SG of individual cadavers was carried out.

In a total of 25.81% cadavers, the external diameter of the SG was smaller than normal (1 SD or more below the mean external diameter), and it was bilateral in 16.13% cadavers and unilateral in 9.68% cadavers. The mean external diameter of the smaller arteries was 0.95 ± 0.02 mm and 0.98 ± 0.01 mm on the left and right sides respectively. In a total of 20.97% cadavers, the external diameters of the SG were larger than normal (1 SD or more above the mean external diameter), and it was bilateral in 17.74% and unilateral in 3.23% cadavers. The mean external diameter of the larger arteries was 1.64 ± 0.04 mm and 1.69 ± 0.03 mm on the left and right sides respectively. There was no significant difference in mean external diameters between the two sides ($p > 0.05$) and males and females.

In 95.16% the IG showed normal origin. However in one male specimen (1.61%) on the left side, the OA originated from the IG (Figure 2). In two other specimens, one (1.61%) male (left side) and one (1.61%) female (right side), the SG, IG and LS originated as a common trunk from the posterior division of the internal iliac artery (Table 3) (Figure 3). No variations were observed on the opposite side in any of the cadavers. The mean length of the IG was 4.41 ± 0.11 cm on the left side and 4.45 ± 0.14 cm on the right side. The mean external diameter of IG was 1.81 ± 0.95 mm on the left side and 1.87 ± 0.99 mm on the right side.

In a total of 14.52% cadavers, the external diameters of the IG were smaller than normal. The decrease in external diameter was bilateral in 8.06% and unilateral in 6.45% cadavers. The mean external diameter of these smaller arteries was 0.95 ± 0.01 mm and 0.97 ± 0.02 mm on the left and right sides respectively. In 11.29% the external diameters of the IG were larger than normal. The increase in external diameters was bilateral in 8.06% and unilateral in 3.23%. The mean external diameter of the large arteries was 2.49 ± 0.11 mm and 2.51 ± 0.03 mm on the left and right sides respectively. There was no significant difference between the two sides or between male and female ($p > 0.05$).

Considering the variations in diameters of the SG and IG further analysis of all the female pelvic halves was carried out to determine if a

relationship exists between the external diameters of these two arteries. In 16.13% the external diameters of the SG were smaller than normal on both sides. Of these pelvic halves, in 6.45% the external diameters of IG were also bilaterally large. In 17.74% the external diameter of SG was bilaterally large, while the external diameter of the IG was bilaterally small in 9.68%.

Discussion:

A detailed cadaver-based identification is crucial in the avoidance of iatrogenic injury of SG and IG and their branches and the use of perforator flaps in plastic reconstructive surgery of the breast. All vascular dimensions were recorded using electronic digital calipers which have a high resolution and accuracy. In addition, the reliability of the methods of measurements used in this study have also been previously confirmed by three-dimensional digital image correlation (3D-DIC) studies, high-resolution B-mode ultrasound, and direct in vivo measurements[7]. The accuracy of the measurements in this study was further reconfirmed by comparing dimensions obtained using slide calipers with measurements using digital stereo images of arteries using digital CCD Point Grey cameras with an image resolution of 1028×768 pixels.

In a majority of cadavers, the SG had a normal course and is similar to previous reports in Caucasian[8] and Thai populations. However, variations were seen in the SG, wherein one cadaver (1.61%) it provided origin to the OA, while in another cadaver (1.61%), the SG and IG originated as a common trunk along with the LS. The mean length of the SG was 7.07 ± 0.18 cm on the left side and 7.04 ± 0.11 cm on the right side. The mean external diameter of SG was 1.26 ± 0.22 mm on the left side and 1.28 ± 0.21 mm on the right side. The length of the SG in this study is comparable to previous values in Caucasian populations where the reported lengths were $5.7-6.6$ cm⁸, $3.99-4.01$ cm and $4.09-4.67$ cm⁹. However, they were not comparable to a Thai population of $6.44-7.33$ cm.

Variations were seen in the IG, wherein one cadaver (1.61%) it provided origin to the OA, while in another cadaver (1.61%) the SG and IG originated as a common trunk along with the LS. The mean length of the IG was 4.41 ± 0.19 cm ($4.28-4.49$ cm) on the left side, and 4.45 ± 0.24 cm on the right side. The mean external diameter of IG was 1.81 ± 0.95 mm on the left side and 1.87 ± 0.99 mm on the right side.

This is the first cadaveric study to examine the external diameter of the SG and IG. A striking observation in this study was the variations in the external diameters of the SG (38.71%) and IG (25.81%). More clinically significant the SG was bilaterally narrower than normal (16.13%), the IG was bilaterally larger than normal (9.68%). Correspondingly, in cadavers where the SG was bilaterally wider than normal (17.74%), the IG was bilaterally narrower than normal (8.06%). These observations suggest that the gluteal region has complementary blood supply from the SG and IG. This supports the findings of a seminal study by Song et al., 2006, which reported that in 47.3% cases the predominant blood supply was from the IG, while in 13.5% of the predominant blood supply was from the SG. In the remaining (39.2%) the gluteal muscles received equal blood supply from the SG and IG[9]. The complementary supply of the muscles of the gluteal region has also been recently reported in computed tomographic angiography studies of the gluteal region in patients[10]. This observation has great clinical relevance in perforator flap surgery where the use of customized perforator flaps from the gluteal region have become a very popular method for breast reconstruction[5] and repair of defects of the perineum[6]. A perforator flap consists of the skin and underlying tissue that is perfused by an isolated artery whose branches penetrate into deeper structures within the flap[2]. The success of such perforator flaps is based on the adequacy of the arterial supply of the branches of SG[6] and IG[11].

The significant finding of this study is the variations in the SG and IG and their branches. These variations are probably due to an unpredictable[12] the pattern of formation of the arteries in the pelvic part of the abdominal cavity and lower extremity during development. The final arterial pattern is a result of the union of vascular channels which were initially homogenous capillary plexuses[11]. During embryological development, the most appropriate channels connecting these two plexuses enlarge, while others retract and disappear[13].

Conclusions:

There are some limitations in angiographic investigations. Studies

using embalmed human bodies are still vital in the elucidation of the arterial supply of the gluteal region. Such information would be a valuable adjunct to CT and ultrasound investigations.

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Conflict of interest:

The authors declare no conflict of interest.

Table 1: Summary of mean $\pm$ SD (range) of length and mean external diameter of branches of the SG and IG.

Name of artery	Length (cm) (Left side) {Mean $\pm$ SD} [Range]	Length (cm) (Right side) {Mean $\pm$ SD} [Range]	Mean external diameter (mm) (Left side) {Mean $\pm$ SD} [Range]	Mean external diameter (mm) (Right side) {Mean $\pm$ SD} [Range]
Inferior gluteal artery	{4.41 $\pm$ 0.11} [4.28-4.59].	{4.45 $\pm$ 0.14} [4.28-4.61].	{1.81 $\pm$ 0.95} [0.94-2.52]	{1.87 $\pm$ 0.99} [0.96-2.55]
Superior gluteal artery	{7.07 $\pm$ 0.18} [6.98-7.18]	{7.04 $\pm$ 0.11} [7.88-7.18].	{1.26 $\pm$ 0.22} [0.91-1.82]	{1.28 $\pm$ 0.21} [0.95-1.99]

Table 2: Summary of variations of the superior gluteal artery

#	Left/right	Gender	Variation
	Right	Female	The obturator artery (OA) originated from the superior gluteal artery (SG). No variation was observed on the opposite side.
1	Left	Male	The superior gluteal artery (SG), inferior gluteal artery (IG) and lateral sacral artery (LS) originated as a common trunk from the posterior division of internal iliac artery (IIA) on the left side. No variation was observed on the opposite side.
2	Right	Female	The superior gluteal artery (SG), inferior gluteal artery (IG) and lateral sacral artery (LS) originated as a common trunk from the posterior division of internal iliac artery (IIA) on the left side. No variation was observed on the opposite side.

Table 3: Summary of variations of the inferior gluteal artery

#	Left/right	Gender	Variation
1	Left	Male	The obturator artery (OA) originated from the inferior gluteal (IG). No variation was observed on the opposite side.
2	Left	Male	The superior gluteal artery (SG), inferior gluteal artery (IG) and lateral sacral artery (LS) originated as a common trunk from the posterior division of internal iliac artery (IIA) on the left side. No variation was observed on the opposite side.
3	Right	Female	The superior gluteal artery (SG), inferior gluteal artery (IG) and lateral sacral artery (LS) originated as a common trunk from the posterior division of internal iliac artery (IIA) on the left side. No variation was observed on the opposite side.

FIGURE LEGENDS

Figure 1: The origin of the obturator artery (OA) from the superior gluteal artery (SG). Scale bar represents 1 cm.

Figure 2: The origin of the obturator artery (OA) from the inferior gluteal artery (IG). Scale bar represents 1 cm.

Figure 3: The superior gluteal artery (SG), inferior gluteal artery (IG) and lateral sacral artery (LS) originated as a common trunk from the posterior division of internal iliac artery (IIA). Scale bar represents 1 cm.

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