TECHNICAL NOTE

An In Vivo Radiologic Description of Periacetabular Vascularization in a Healthy Subject and a Literature Review of its Clinical Implications

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Abstract

The aim of this study is to provide a radiologic description of periacetabular vascularization. A computed tomography angiography was used to analyze the vascularization patterns of the periacetabular region, describing for the first time "in vivo" the periacetabular branches of the superior and inferior gluteal artery, obturator artery, and of the medial circumflex femoral artery. The analysis revealed the possibility of visualizing clearly all the previously described vessels of the aforementioned arteries. Both acetabular and supra-acetabular arteries, the rami of the OA directed to the lamina quadrilateral, and the rami of the IGA directed to the posterior wall were identified. In conclusion, understanding the periacetabular vascularization patterns is pivotal for effective clinical decision-making in pelvic trauma, and conservative and reconstructive surgery of the hip. The radiologic description provided in this study, along with the associated literature review, offers valuable insights into the clinical implications of periacetabular vascularization.

Level of evidence: V

Keywords: Acetabular artery, Acetabular osteotomy, Computed tomography angiography, Pelvic trauma, Periacetabular vascular ring, Periacetabular vascularization, Supra-acetabular artery

Introduction

The blood supply to the acetabulum is essential for various surgical procedures including management of pelvic trauma, hip preservation and complex reconstruction surgery.[1,2] However, the description of the periacetabular vascularization remains limited compared to the proximal femur.[3] The periacetabular ring consists of several arteries, including the superior gluteal artery (SGA), inferior gluteal artery (IGA), obturator artery (OA), medial circumflex femoral artery (MCFA) and their anastomosis [Figure 1].[4] Previous studies on periacetabular vascularization primarily focused on cadaveric specimens, particularly concerning periacetabular osteotomies. [4-8] Avascular necrosis of the osteotomy fragment was initially observed as a complication after rotational acetabular osteotomy (RAO).[9,10] While the importance of periacetabular vascularization for surgical procedures is recognized, there is a lack of comprehensive *in vivo* descriptions and their radiological counterpart.

In pelvic trauma, angioembolization carries recognized complications that can potentially cause disability.[9] These complications include massive gluteal necrosis, impotence, sciatic nerve injuries, deep infection, bladder necrosis, and urethral necrosis.[9] The limited selectivity of angioembolization towards smaller arteries may play a key role. However, advancements in angioembolization techniques hold promise for greater selectivity in targeting even smaller bleeding arteries[9]. Precise anatomical knowledge of the periacetabular vascular ring will aid in navigation during angioembolization procedures, leading theoretically to a decrease in complications.[9]

The objective of this study is to provide a comprehensive understanding of the periacetabular vasculature by conducting an in vivo radiologic description in a healthy subject. Previous studies have primarily relied on cadaveric investigations. Additionally, the study includes a literature review that explores the clinical implications of these findings.

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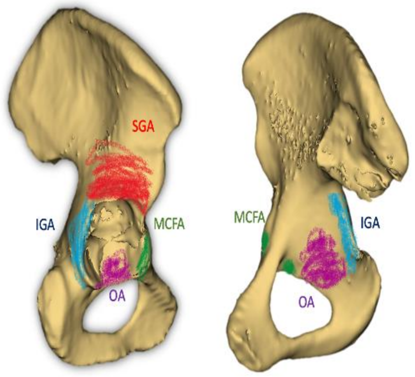

Figure 1. The "periacetabular vascular ring" consist of a group of arteries that provide blood supply to the periacetabular area. The arteries of the periacetabular vascular ring are: the Superior Gluteal Artery, the Inferior Gluteal Artery, the Obturator Artery, and the Medial Circumflex Femoral Artery. The SGA is responsible for the vascularization of the superior area and of the roof of the acetabulum, the IGA provides the vascularization of the posterior region and of the posterior wall of the acetabulum, the OA provides the vascularization of the inferior area and of the floor of the acetabulum, the MCFA provides the vascularization of the anterior-inferior region of the acetabulum.Abbreviations: SGA = superior gluteal artery; IGA = inferior gluteal artery; OA = obturator artery; MCFA = medial circumflex femoral artery

Surgical Technique

Computed Tomography Angiography (CTA) Protocol

We obtained the clinical and radiographic data of a 31-year-old patient who underwent an angio-CT scan for reasons unrelated to pelvic trauma, hip disorders, or neoplasia. The CT was performed using a 0.6mm slicing thickness (SOMATOM go.Top, Siemens Healthineers, Germany).

The protocol was optimized for the angiographic phase after the administration of contrast media. It included an axial acquisition covering the level of the aortic bifurcation and extending to the distal third of the femoral diaphysis. Subsequently, an angiographic series was acquired following intravenous administration of iodinated contrast media (Ultravist 370 ml/ml, Bayer, Germany). The acquired images were processed using the syngo.via-CT Workplace Software VA.

Description of periacetabular vascularization

Superior Gluteal Artery

The SGA originates from the posterior trunk of the internal iliac artery. It divides into a superficial and deep branch after 5.9mm at the suprapiriformis canal. The deep branch further divides into four branches which provide the periacetabular vascularization [Figure 2].

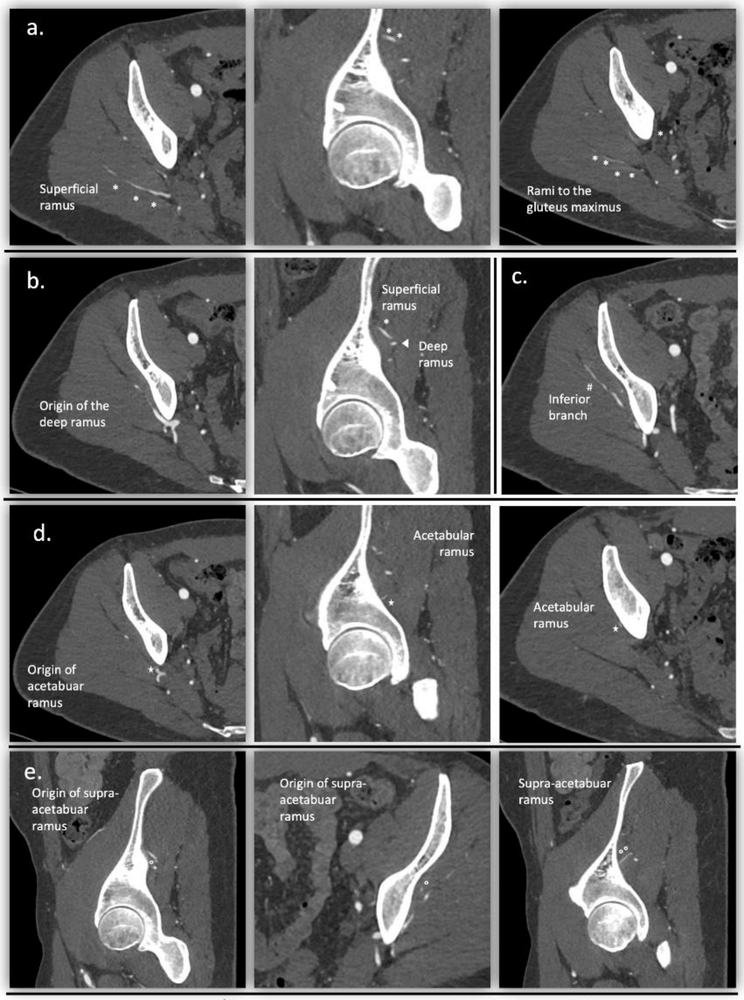

Figure 2. Superior gluteal artery and its branches: (a) the superficial branch of the SGA provides blood supply to the gluteus maximus and medius. In the third images from the left are visibles two small rami that enters into the body of the gluteus maximus. (b) The deep ramus of the SGA divides into a superior and inferior branches after 14.5 mm from its origin. (c) The inferior branch is directed towards the tensor fascia lata muscle. (d) Acetabular ramus, also knows as the artery of the roof of the acetabulum originates directly from the deep ramus of the SGA, it is directed antero-inferiorly reaching the acetabular roof. (e) The supra-acetabular ramus originate from the superior ramus of the deep SGA. It goes inferiorly within the body of the gluteus minimus reaching the acetabular roof

Superficial branch: This branch ascends between the gluteus medius and gluteus maximus muscles, ultimately terminating as a perforating vessel. Along its pathway, there are several small rami that irrorate the gluteus maximus muscle [Figure 2a].

Deep branch: The deep branch further divides into a superior and inferior branch after 14.5mm from its origin.

The superior ramus extends towards the upper edge of the gluteus minimus, aiming towards the anterior-superior iliac spine. During its course, three small rami irrorate the body of the gluteus medius. The inferior ramus courses along the lateral aspect of the gluteus minimus reaching the tensor fascia lata [Figures 2b and 2c].

Acetabular ramus: This artery originates directly from the deep branch of the SGA, 3.7 mm prior to the division into the superior and inferior rami. It courses around 25mm from the acetabular margin, lying between the gluteus minimus and the pelvis [Figure 2d].[6,7]

Supra-Acetabular Ramus: The supra-acetabular ramus arises from the superior ramus of the deep SGA. It courses within the muscular body of the gluteus minimus, directed antero-inferiorly towards the acetabular roof, and extends to the interspinous crest. In this case, the origin of the acetabular ramus differed from the most commonly reported findings by Beck et al. where it was found to originate from the inferior ramus in 50% of cases [Figure 2e].[6]

Obturator Artery

In this patient, the obturator artery (OA) originates from the anterior trunk of the internal iliac artery (IIA). It follows an antero-inferior course along the lateral side of the pelvic wall, running parallel to the obturator nerve, until it reaches the upper part of the obturator foramen. It then exits the pelvis through the obturator canal, after which it divides into three branches: the anterior branch, posterior branch, and acetabular (or medial) branch [Figure 3].

Rami to the quadrilateral plate: During its course, the OA gives off small rami that supply the quadrilateral plate. In this case, we observed two small vessels as shown in [Figure 3a].

Anterior branch: The anterior branch of the OA supplies the external obturator muscle and the superior pubic ramus [Figure 3b].

Posterior branch: The posterior branch follows the superior border of the obturator foramen, providing small vessels to the inferior acetabulum [Figure 3c].

Medial branch: The acetabular or medial branch enters the hip joint through the incisura acetabuli under the transverse ligament. Inside the joint, it gives rise to a branch that supplies the round ligament and four small branches that reach the acetabular fossa [Figure 3b].

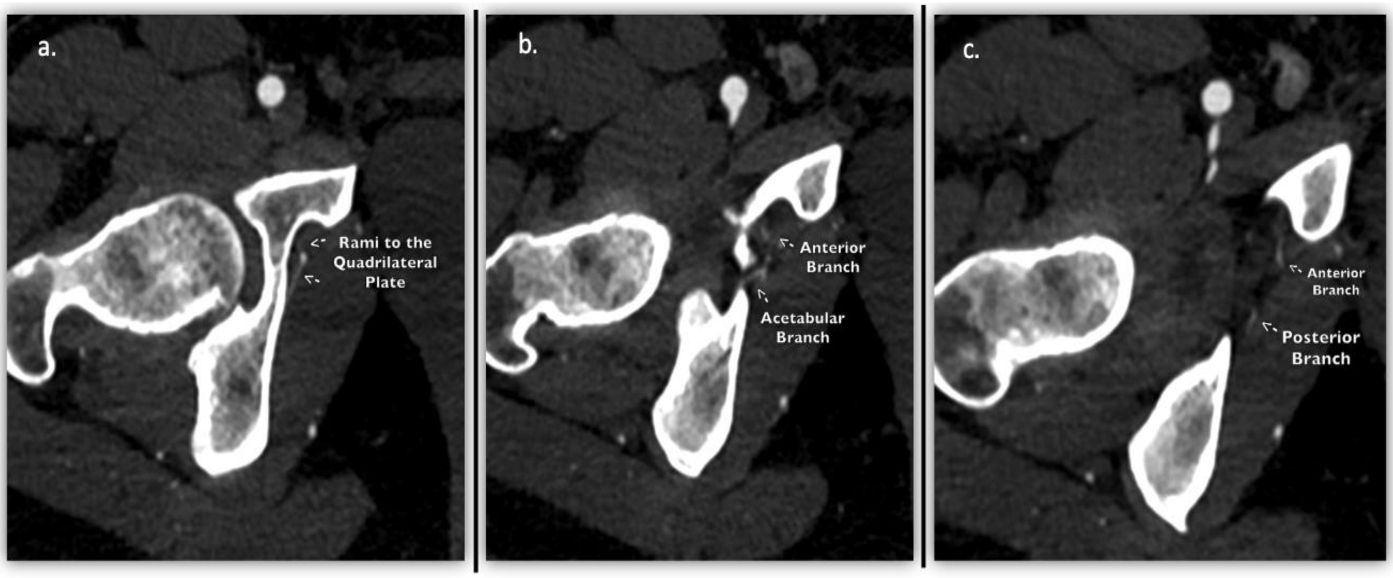

Figure 3. Figure 3 Branches of the Obturator Artery. (a) Rami to the quadrilateral plate. The OA provides three to four small rami directed to the quadrilateral plate. (b) Anterior and acetabular branches. The anterior branch of the OA goes anteriorly reaching the superior pubic ramus providing blood supply to the bone and to the obturator external muscle. The acetabular branch of the OA enter the hip's joint below the transverse ligament providing blood supply to the acetabular roof and to the round ligament. (c) The posterior branch of the OA follow the superior margin of the obturator foramen reaching the inferior area of the acetabulum

Inferior gluteal artery

The IGA originates from the anterior trunk of the internal iliac artery and exits the pelvis through the greater sciatic foramen. It runs below the piriformis and descends medially to the sciatic nerve. The IGA gives off muscular branches to the piriformis, as well as a branch to the sciatic nerve. Additionally, we observed the presence of two small branches directed towards the posterior wall of the acetabulum [Figure 4a].

Medial Circumflex Femoral artery

There were two branches originating from the deep branch of the MFCA that supplied the acetabulum. One branch provided blood supply to the anterior inferior joint capsule, while the other ran alongside the pectineus muscle's lateral border. This branch supplied the antero-inferior region of the acetabulum [Figure 4b].

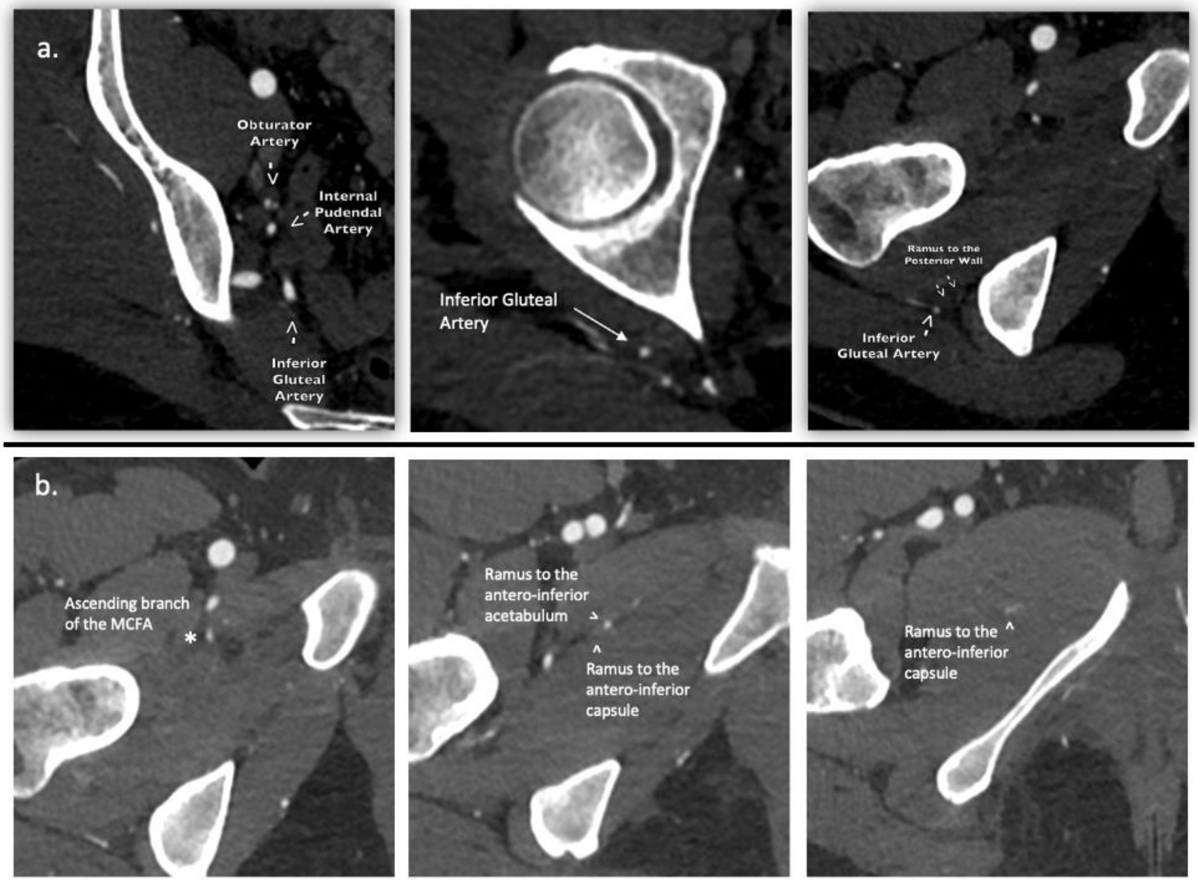

Figure 4. Figure 4 Inferior gluteal artery and Medial circumflex Femoral Artery. (a) The inferior gluteal originates at the anterior trunk of the internal iliac artery. Running inferiorly below the gluteus mininus to provide vascularization of the posterior wall of the acetabulum with three to five small rami. (b) The Medial Circumflex Femoral Artery originates at the posterior trunk of the profunda femoris. It didived into an ascending and descending branches at the femoral neck. The ascending branch is responsible for the vascularizarion of the antero-inferior hip's capsule and of the anteroinferioe acetabulum

Discussion

This is the first ever in vivo radiologic description of the periacetabular vasculature in a healthy subject. Before this study, the understanding of these vessels was primarily based on cadaveric investigations.[6-10] Trough the CTA we could discern all the arteries involved in vascularizing the acetabulum, including the most peripheral branches of the SGA, IGA, OA and MCFA. If previous studies were able to offer a thorough description of principal SGA branches in cadaveric specimens, this study could corroborate these findings in vivo.[6-8]

The complex course and smaller size of the supra-acetabular artery may pose challenges for standard imaging techniques. Cook described various routes through the lumbosacral plexus, with the most common being the SGA passing between the lumbosacral trunk and the anterior ramus of the S1 nerve, followed by a lateral pattern where the SGA runs alongside the lumbosacral trunk. [3] Within the context of vascular supply to the periacetabular area, the IGA demonstrates its significance by providing two to three branches to the posterior wall. Despite the relatively modest diameter of these vessels, their contribution to the blood supply of the acetabulum should not be disregarded. Additionally, Beck et al. described anastomoses between the IGA, SGA, and OA at this level, which were not visible with the CT scan technique in this case.[4]

Avascular necrosis of the distal fragment is a potential complication during rotational osteotomy (RAO), as noted by Itokazu.[8] our findings confirm that the anterior osteotomy interrupts the iliolumbar artery, while the sacrifice of the SGA occurs in the region of the superior osteotomy. Additionally, the rami of the IGA directed to the posterior acetabulum are sacrificed during the posterior osteotomy. [4,8] According to Matsumoto et al., the blood flow of the free fragment can be reduced up to 66% during RAO.[10] Concerning periacetabular osteotomy (PAO), Beck et al. suggested special attention to the rami of the SGA and IGA, as they can be slightly stretched during the mobilization of the acetabular fragment.[4,6] Although the vessels remain intact, there may be a slight reduction in blood flow as suggested by eco-doppler studies.[4] The OA is not typically damaged during PAO, and careful detachment of the iliac muscles is advised by keeping strictly subperiostal and avoiding extension to the obturator foramen.[4] The MCFA is generally not affected during these procedures, as observed in the study by Kalhor et al.. The role of capsular and pericapsular vessels becomes especially important when principal branches are compromised as in acetabular osteotomies.[6,7] Preserving the capsular attachment to acetabular fracture fragments is crucial for minimizing the risk of avascular necrosis and preserving bone healing.[4]

The result of our study could also improve radiologic navigation during arterial embolization in pelvic trauma[9]. Pelvic angioembolization plays a crucial role in the management of life-threatening pelvic ring fractures.[9] by assessing the arterial anatomy, interventional radiologists could be more precise. Non-selective embolization in the pelvic region can lead to severe complications, including muscle necrosis, sciatic nerve palsy, and bladder necrosis.[9]

Conclusion

In conclusion, this study presents a comprehensive review of periacetabular vascularization through an in vivo radiologic description in a healthy subject. These findings have important clinical implications for surgical procedures, particularly in the context of periacetabular osteotomies and angioembolization in cases of pelvic trauma.

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