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CASE REPORT

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Unique branching pattern of the internal iliac artery accompanied by a supernumerary internal iliac vein

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Understanding the complex vascular anatomy of the lesser pelvis is vital in diagnostics and management of numerous pathologies in gynaecology, urology, orthopaedics and general surgery. The following case reports describes an unusual, undescribed branching pattern of the internal iliac artery with additional specific branches, as well as an unprecedented supernumerary internal iliac vein. Both clinical significance and embryology of the case are discussed. (Folia Morphol 2024; 83, 2: 444–450)

Keywords: internal iliac artery, internal iliac vein, case report

INTRODUCTION

The internal iliac artery (IIA), otherwise described as the hypogastric artery, is the main blood vessel supplying the pelvic floor and walls, buttocks, internal and external reproductive organs, urinary bladder, rectum and neuro-muscular structures of the lumbar and femoral region. Its mean length varies from 3 to 4 cm. Its origin can be located anteriorly to the pelvic brim, where it arises from the common iliac artery. The artery descends anteriorly until it enters the lesser pelvis where it divides into its two main branches: the posterior and the anterior trunk [14].

The posterior trunk runs vertically down and passes towards the greater sciatic foramen, exiting the pelvic cavity above the piriformis muscle. Its minor branches include the iliolumbar and lateral sacral arteries, with a terminal branch at the superior gluteal artery. The anterior trunk passes forward and down, close to the inner pelvic wall, until it reaches the lower section of the sciatic foramen. It gives rise to six visceral branches: the umbilical artery, the superior vesical artery, the inferior vesical artery, the middle rectal artery and additionally in women, the vaginal artery and the uterine artery. The parietal branches of the anterior trunk include the obturator artery and the inferior gluteal artery, which is its termination.

The internal iliac vein or the hypogastric vein serves as the main venular vessel draining blood from both walls and organs of the pelvis as well as the sacrum and the coccyx. It is usually 3 cm long and arises above the greater sciatic foramen running upwards and merging with the external iliac vein forming the common iliac vein. Its structure and division is even more unpredictable and irregular than that of the internal iliac artery. Its tributaries include branches corresponding with those of the internal iliac artery; however, their point of entry may not be symmetrical. Its main clinical significance includes posing an alternate circulatory route should the external iliac veins be occluded.

Due to its considerable variability, there have been many attempts at classifying the elusive branching pattern of the IIA. One of the most popular and clinically-viable classifications is the one proposed

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by Adachi [2]. Since its creation, it served as a base for many other researchers such as Al Talalwah and Soames [3], Ashley and Anson [6] and Balcerzak [8] who have updated and improved upon it. Despite the recent creation of new and extensive systems of classification, many case reports present extreme and unique variations not included in any paper to date.

CASE REPORT

A female cadaver 81 years old at death was subjected to routine dissection for scientific and educational purposes at the Department of Anatomical Dissection and Donation, Medical University of Lodz. The abdomen was dissected and both kidneys and sections of the large intestine have been removed. Resection of surrounding adipose and fibrous tissue exposed vascular structures of the pelvis. Analysis of the course and branching pattern of the internal iliac artery and internal iliac vein revealed a peculiar vascular anomaly.

The diameters of individual branches were measured with a digital calliper. Further dissection of the branching area exposed a unique branching pattern that has not yet been described to our knowledge. Apart from the arterial variation, an additional, supernumerary internal iliac vein was present.

The internal iliac artery (IIA) begins its course at the bifurcation of the common iliac artery (CIA) located at the level of the fourth lumbar vertebrae. It then descends alongside the posterior pelvic wall until it reaches the lower brim of the fifth lumbar vertebrae where its branching pattern is located. The iliolumbar artery (ILA) originates independently from the main trunk at the level of the upper brim of the fifth lumbar vertebrae. It then wraps around the branching point of the proximal internal iliac vein (PIIV) and divides into its terminations at its posterior surface. The lumbar branches originating from the ILA are hypoplastic while the iliac branch passes the psoas major and runs laterally towards the iliac crest. At the branching point, three major branches stem from the IIA. The most lateral one of them is a supernumerary branch extending towards the psoas major. Upon reaching the posterior side of the muscle, the artery bends down at a 90 degree angle and runs straight downward in vicinity of the genitofemoral nerve. The artery gives off lateral and terminal branches supplying the lower section of the psoas major, which explains the limited size of the lumbar section of the ILA.

The posterior trunk (PT) has an arched course. After branching out of the main trunk it runs medially for about 2 cm before bending laterally and passing behind the IIA branching point. It leaves the pelvic cavity as the superior gluteal artery above the piriformis muscle and between the fifth lumbar and first sacral root of the sacral plexus. The lateral sacral artery (LSA) branches out of the PT at its most medial point and runs medially towards the sacrum where it gives off its terminations. The anterior trunk is practically nonexistent, and measures about 3 mm. It runs vertically down before dividing into the uterine artery (UtA), the inferior gluteal artery (IGA) and a common trunk for the umbilical artery (medial umbilical ligament) and the superior vesical artery (SVA).

The IGA passes down towards the pelvic floor and bends medially before diverting its course laterally and giving off a common trunk for three terminal branches, two of which are accessory. The upper branch bends upwards and laterally, after which it runs alongside the upper margin of the obturator foramen. Upon making contact with the internal obturator muscle its diameter substantially decreases and the artery starts giving off terminal branches, suggesting that it is in fact an accessory branch of the internal iliac artery tasked with supplying the internal section of the internal obturator muscle. The second branch of the common trunk is the obturator artery (OA), which runs anteriorly and laterally until exiting the pelvic cavity via the obturator canal. Further dissection and analysis of the OA's course ruled out the presence of a "corona mortis" anastomosis. The third and final branch of the common trunk bends downwards and heads straight towards the pelvic floor until reaching the first lumbar nerve root where it bends laterally and enters the sacral plexus running directly between its fibres. Further dissection of the plexus revealed that the unique branch gives off miniature terminal branches within the nervous structure thus providing additional blood supply.

After giving off the common trunk, the IGA continues its downward course for approximately 3 cm and gives rise to an internal pudendal artery (IPA), which runs anteriorly and laterally before exiting the pelvic cavity through the greater sciatic foramen. The IGA then continues its course and leaves the pelvic region below the piriformis muscle. Further analysis of the IGA's termination ruled out the presence of a persistent sciatic artery.

Figure 1. Internal iliac artery and internal iliac veins seen from the anteromedial perspective; 1 — common iliac artery; 2 — external iliac artery; 3 — internal iliac artery; 4 — distal internal iliac vein; 5 — proximal internal iliac vein; 6 — proximal venous anastomosis; 7 — distal venous anastomosis; 8 — superior gluteal artery; 9 — lateral sacral artery; 10 — umbilical artery remnant (median umbilical ligament); 11 — obturator artery; 12 — obturator vein; 13 — vesical vein; 14 — uterine artery; 15 — inferior gluteal artery; 16 — internal pudendal artery.

A significant variation of the internal iliac vein has also been noted, in which a singular internal iliac vein is replaced by two separate vessels labelled the proximal and distal internal iliac vein due to their proximity and relations. However, this variation remains poorly described. The proximal internal iliac vein (PIIV) has a diameter of 6.76 mm and follows a vertical course along the cadaver's midline. It is initially formed within the pelvic cavity, by the junction of superior and inferior gluteal veins. From that point it runs upwards along the sacrum until it reaches the common iliac vein, which is formed by the connection of the external iliac vein and the distal internal iliac vein. Along its course, the PIIV receives two main tributaries: the lateral sacral vein and an unnamed parietal vein, both of which join with it near the pelvic floor. The supply area of PIIV tributaries closely resembles that of the posterior trunk of the internal iliac vein, excluding the connection with the inferior gluteal vein.

The distal internal iliac vein (DIIV) has a comparable diameter of 5.39 mm but poses significantly more tributaries. It arises from a junction of the vaginal and internal pudendal veins within the pelvic cavity. It follows a sinuous course circling the bladder and later running along the pelvic brim before shifting upwards and joining the external iliac vein to create the common iliac vein. Its tributaries include the vesical vein, obturator vein and minor parietal vessels. The supply area of DIIV tributaries corresponds to that of the anterior trunk of the internal iliac vein. Since both internal iliac veins take over the function of both trunks of the IIV, it is therefore likely that the IIV has not been developed during fetal life and the trunks arise independently from the common iliac vein as separate vessels. Both IIVs anastomose twice with each other. The proximal anastomosis has a diameter of 3.14 mm and passes posteriorly to the main trunk of the IIA. The distal anastomosis is 2.29 mm in diameter and runs anteriorly to the main trunk of the IIA. (Fig. 1) The iliolumbar vein accompanies the iliolumbar artery and joins the common iliac vein directly. Measurements of all structures of interest have been contained in Table 1.

DISCUSSION

Variations in the branching pattern of the IIA are known to have an embryological background [1, 26]. The development of the IIA is closely tied to that of the umbilical arteries (UAs), which are crucial during fetal life. The UAs are formed when the embryo is less than 1.5 mm long. They arise in the posterior section of the embryo from the ventral roots of the dorsal primitive aorta, around the region where the fourth cervical mesodermal somite will later develop. They are formed on the lateral walls of a caudal section of the primitive gut by anastomosis of the caudal ventral or vitelline branches of the primitive aorta. Those precursors of the UAs move caudally as the embryo grows, until they branch out of the aorta opposite the 23rd body somite, which is the fourth

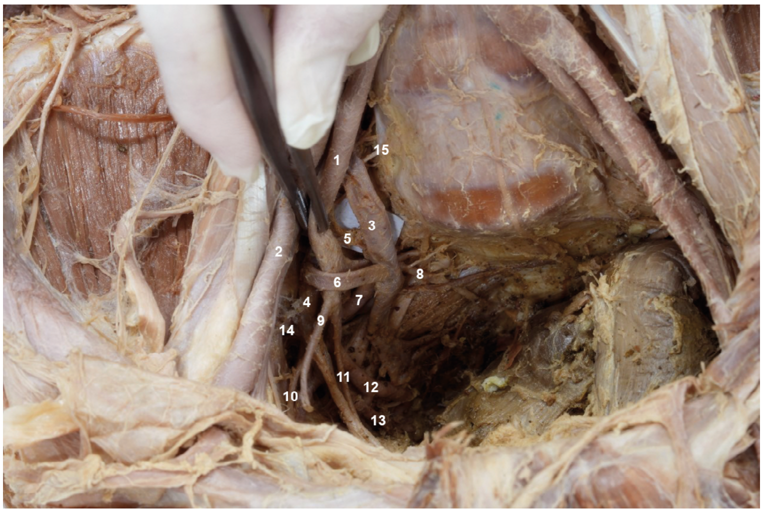

Figure 2. Branching point of the internal iliac artery and venous anastomoses seen from the anteromedial perspective; 1 — internal iliac artery; 2 — external iliac artery; 3 — proximal internal iliac vein; 4 — distal internal iliac vein; 5 — proximal venous anastomosis; 6 — distal venous anastomosis; 7 — superior gluteal artery; 8 — lateral sacral artery; 9 — umbilical artery remnant (median umbilical ligament); 10 — obturator artery; 11 — uterine artery; 12 — inferior gluteal artery; 13 — internal pudendal artery; 14 — accessory internal obturator artery; 15 — iliolumbar artery (terminal lumbar branch).

Figure 3. Pelvic vasculature seen from the anteromedial perspective; 1 — common iliac artery; 2 — external iliac artery; 3 — internal iliac artery; 4 — external iliac vein; 5 — distal internal iliac vein; 6 — proximal internal iliac vein; 7 — distal venous anastomosis; 8 — lateral sacral artery; 9 — superior gluteal artery; 10 — umbilical artery remnant (median umbilical ligament); 11 — obturator artery; 12 — obturator vein; 13 — uterine artery; 14 — inferior gluteal artery; 15 — vesical vein; 16 — internal pudendal artery.

lumbar segment. As fetal development progresses, each UA gains access to a dorsal branch of the aorta, later known as the common iliac artery. In the caudal section of the anastomosis, the external iliac artery begins to form as an extension for the lower limbs. After birth, proximal sections of the UAs develop bilaterally, creating IIAs, whereas distal sections atrophy and transform into the medial umbilical ligament.

Anatomical variants of the IIV have not been covered thoroughly in literature. However, prior reports have described cases of absence or duplication of the iliac veins and inferior vena cava [7, 18, 21], as well as various patterns of draining and fenestration [22]. The coexistence of a supernumerary IIV and two anastomoses connecting it with its counterpart makes our case unique. Since both anastomoses remain in close proximity, the structure of the IIVs resembles a venous ring, which the IIA passes through before giving off its terminal branches, potentially creating a risk of compression should the venous

Table 1. Measurements of structures of interest

Structure	Diameter [mm]
Internal iliac artery	5.39
Anterior trunk	3.31
Posterior trunk	4.76
Iliolumbar artery	2.54
Lateral sacral artery	2.58
Uterine artery	1.58
Superior vesical artery	0.37
Umbilical ligament	1.73
Obturator artery	1.20
Acc. sacral plexus artery	1.79
Interior pudendal artery	2.27
Superior gluteal artery	4.54
Inferior gluteal artery	3.58
Acc. psoas major artery	1.37
Acc. internal obturator artery	0.34
Proximal internal iliac vein	6.76
Distal internal iliac vein	5.39
Proximal anastomosis	3.14
Distal anastomosis	2.29
Distance between anastomoses	10.15

pressure increase. This is further aggravated by the distal internal iliac vein's course passing between the branching points of the umbilical artery remnant and the uterine artery. Due to the iliac vein duplication, the posterior iliac vein is located more medially then in single-vein cases. This causes it to rest on top of the lateral sacral artery, which due to its small diameter is prone to compression.

Complexity of the pelvic vascular systems highlights the importance of a good understanding of retroperitoneal anatomy and its possible variations. Such knowledge proves invaluable to surgeons and clinicians, especially urologists [4], gynaecologists, obstetricians [23], and general surgeons [15, 25]. There is pressing need for accurate descriptions of pelvic vascularization in laparoscopic surgery, in order to prevent iatrogenic damages [28].

The branching pattern presented here somewhat resembles type IIa in the Balcerzak classification because of the following consistencies: the IGA and IPA originate from a common trunk, the PT branches out of the main trunk independently and the division takes place within the pelvic cavity. However many anomalies such as three supernumerary branches and an extraordinarily complex branching pattern cause the presented case to differ significantly from types described in available classification systems. Additionally, the presence of doubled internal iliac veins anastomosing with each other is previously undescribed and makes the overall vascularization pattern peculiar.

Arterial haemorrhage remains one of the most dangerous complications of pelvic fractures and is a leading cause of death related to them [27]. It is also a major cause of maternal morbidity in developing countries. Bilateral IIA ligation is a life-saving treatment method, allowing surgeons to manage pelvic and obstetric haemorrhage. It can also be implemented unilaterally in order to treat aneurysms within the branches of the IIA. Ligation is an invasive procedure during which a certain portion of the artery is closed off to limit blood flow. For that reason, it requires flawless understanding of the retroperitoneal anatomy and possible anatomical variations [24]. In the presented case for example, the unusual course and branching pattern of the internal iliac artery may confuse the operating team should they decide to insert the catheter into a specific branch of the artery.

The supernumerary branch supplying the sacral plexus has immense clinical significance. Its proximity to the nerve roots poses a considerable risk of an extra spinal sciatica should the course of the vessel be altered. A review conducted by Konstantinou showed that the prevalence of sciatica ranged from 1.2 to 43% among different studies [20]. It is unclear whether the anomaly caused the cadaver any discomfort during life; however, it has doubtlessly increased a risk of compression syndromes due to the potential for capillary malformations. Even a small dilation (for example an aneurysm) of the described branch can cause considerable pressure on the sacral plexus, which in turn would result in symptoms such as pain in the lower extremity, paraesthesia alongside the thigh or even weakening of motor functions of the leg [19]. Although rare, somewhat similar cases have been described: a case study by Geelen et al. [16] reports a case of a 73-year-old woman with severe sciatica caused by an aneurysm of the internal iliac artery mimicking a disc herniation.

The presence of two internal iliac veins can also have favourable clinical consequences. In the event of a thrombotic obstruction of external iliac systems, the internal iliac veins provide a bypass for the venous return from the femoral system. An additional IIV facilitates the flow of additional blood reducing the pressure it causes, therefore decreasing the risk of related complications. Occlusion of the external femoral systems is a common occurrence for many medical specialties such as gynaecologists, gastroenterologists, orthopaedists and oncologists [5, 9, 11]. It is therefore important to assess the structure of the internal iliac veins and plan management accordingly. Due to the ongoing COVID-19 pandemic, a significant rise in the incidence of DVT has been noted. A case report by Beretta et al. [10] describes a massive cerebral and IIV thrombosis in a COVID patient. In the presented case, the additional vessel would play a crucial role, should such a pathology occur. The second vessel would intercept blood flow from the pelvic cavity, therefore limiting the pressure in the blocked vein and ultimately decreasing the risk of a pulmonary embolism.

Rupture of the internal iliac artery and its branches is a rare but potentially lethal complication that can occur in pregnancy. In a case report describing three instances of utero-ovarian ruptures, Ginsburg et al. [17] estimate the initial overall mortality associated with this phenomenon to be around 49%; however, in recent years a decrease to 3.6% has been noted. The risk is further aggravated by the nonspecific symptoms of rupture, which can lead to incorrect diagnosis and ultimately fetal and maternal death [12]. The causes of ruptures to the IIA and its branches during gestation remain mostly unknown. However, the most common risk factors include a history of previous arterial infection or trauma, high blood pressure in the UtA and ovarian arteries, endometriosis and innate diseases of the connective tissue such as Marfan syndrome or Ehlers-Danlos syndrome type IV. A case study by Calcott et al. [13] describes a 33-year-old primigravida who underwent an emergency caesarean section and a post-natal embolization of the uterine artery. If embolization fails or is unavailable, management of uterine haemorrhage can also be achieved via ligation. In such cases, time is of the essence in order to preserve the health of both mother and child. This underlines the importance of understanding the different patterns and courses of the IIA and its branches. In the discussed case, the presence of an additional internal iliac vein would have obstructed the surgical access in the event that the bleeding originated from the lower section of the artery; this would pose a threat of an additional venous haemorrhage if the delicate structure is severed.

CONCLUSIONS

In conclusion, pelvic vascularization is variable, and creating a comprehensive classification of all anatomical variants is futile. It is therefore important to supplement already existing classifications with case studies such as this one. Pre-operative knowledge of anatomical variants alongside with their course and relations to nearby structures is vital in diagnosis and management of pathologies located within the pelvis.

Conflict of interest: None declared.

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