Branching patterns of the male internal iliac artery: imaging findings

Tiago Bilhim · Diogo Casal · Andrea Furtado · Diogo Pais · João Erse Goyri O’Neill · João Martins Pisco

Received: 22 May 2010 / Accepted: 10 August 2010 © Springer-Verlag 2010

Abstract The aim of this study was to establish the imaging findings of the main branching patterns of the male internal iliac arteries, using different imaging modalities (angio MR, angio CT and digital angiography). Twenty-one males (mean age 73.2 years) underwent imaging evaluation with angio MR, angio CT and digital angiography to define the internal iliac artery anatomy before selective embolization of the pelvic arteries. All three modalities were used in 3 patients, angio MR and digital angiography in 17 patients, angio CT and digital angiography in 6 patients and only angio CT in 1 patient. Internal iliac arteries were classified into four groups using the Yamaki classification (modified from the Adachi’s classification). Twenty-six pelvic sides were classified as Group A (61.9%), 13 as Group B (31%) and 3 as Group C (7.1%) with no cases of Group D found. Angio MR, angio CT and digital angiography were able to detect most branches of the internal iliac artery. Group A was the most frequent internal iliac artery branching pattern. Angio CT showed better detailed anatomy than angio MR and digital angiography was considered the gold-standard. Non-invasive vascular imaging with angio MR or angio CT is essential before invasive interventions, allowing better planning of the procedure.

Keywords Internal iliac arteries · Angio MR · Angio CT · Digital angiography

Introduction

Pelvic vascular anatomy is very difficult to evaluate in cadaveric specimens. There is a major difficulty in using images of fresh frozen tissues due to an inability to resolve structures that are similar in colour and very small in size. The pelvic connective tissue, fat and small nerves and vessels are almost indistinguishable [13]. With the new diagnostic imaging techniques there is the need for an increased understanding of the vascular anatomy of the pelvic region. Multi-slice spiral CT has been applied to study the adult pelvic artery morphology with 3D reconstructions; however, the microvasculature remains hard to be marked and characterized on current CT and MRI scans [2].

Knowledge of the anatomy and anatomic variations of the arteries of the pelvic region has very important clinical and surgical implications. For example, associations between anatomical variations of the internal pudendal artery and erectile dysfunction have been described [6] and the presence, identification and preservation of accessory pudendal arteries has been advocated in artery-sparing radical prostatectomies in order to reduce post-surgical erectile dysfunction [8]. Also, knowledge of the branching patterns of the internal iliac arteries is essential to perform arterial embolization of the pelvis which is routinely performed...
nowadays for numerous different clinical settings such as uterine fibroid embolization, bleeding associated with pelvic trauma after delivery, for locally advanced pelvic tumours not amenable to surgery, or for pelvic arteriovenous malformations [3, 4, 9–11].

The branching patterns of the internal iliac arteries have been classified into four groups, based on cadaveric studies. In this new classification, the internal iliac arteries are classified according to the bifurcation patterns of their main collateral branches (the superior gluteal artery, the inferior gluteal artery and the internal pudendal artery) [14]. However, there are no studies to date describing different imaging modalities for the evaluation of the male branching patterns of the internal iliac arteries.

The purpose of this work is to define the imaging findings of the main branching patterns of the male internal iliac arteries, using different imaging modalities such as angio MR, angio CT and digital angiography. We supply basic imaging anatomy of male internal iliac arteries, regarding the main anatomical variations.

Materials and methods

Imaging evaluation using angio MR, angio CT and digital angiography was performed in 21 male patients (42 pelvic sides). All patients were Caucasian, with a mean age of 73.2 years (range 58–83 years).

Angio MR examinations were performed using a 1.5 T Philips® system. Contrast-enhanced angio MR was performed in 17 patients in the supine position, using a fast 3D spoiled gradient echo scan (T1-FFE; TR 5 ms; TE 1.6 ms, flip angle 40°) with thin sections (slice thickness of 2 mm). Acquisition was performed in axial plane within a single breath-hold (scan average time of 22.9 s). Bolus injection of gadolinium chelate (0.1 mmol/kg), at an injection rate of 2 mL/s was followed by an injection of 30 mL saline at 2 mL/s. Maximum intensity projections (MIP) and volume rendering with 3D reconstructions were performed.

Angio CT examinations were performed using 16 spiral GE® scanner in 7 patients in the supine position. Power settings were 100–120 kV and 200–300 mA, matrix of 512 × 512 pixels, collimation of 16 × 1.25 mm (slice thickness 0.5 mm), pitch of 1.3. Iodine contrast injection of 150 cc (at a concentration of 350 mg/mL iodine), at an injection rate of 5 mL/s using bolus triggering in the abdominal aorta (above the renal arteries) was performed in every patient. Post-processing using MIP and volume rendering with 3D reconstructions were performed.

Digital angiography was performed in 20 patients by a single femoral approach, usually the right side, using a cobra-shaped catheter (C2F5). Digital angiography was first performed in the aorta to visualize both pelvic sides and common iliac arteries (injection volume 30 mL, injection rate of 15 mL/s). Afterwards, contra-lateral (usually the left) internal iliac artery was selectively catheterized and digital angiography (injection volume 15 mL, injection rate of 8 mL/s) was performed in the artery origin in neutral position and repeated with left anterior oblique projection (35°) and caudal-cranial angulation (10°). Same side internal iliac artery (usually the right) was selectively catheterized after performing the Waltman loop on the catheter with same side (usually the right) anterior oblique projection (35°) and caudal-cranial angulation (10°).

All 3 modalities were used in 3 patients, angio MR and digital angiography in 17 patients, angio CT and digital angiography in 6 patients and only angio CT in 1 patient. All patients that underwent these examinations were being evaluated before selective embolization of the pelvic arteries.

Internal iliac arteries were classified using the Yamaki classification [14] (modified from the Adachi’s classification) in four groups. In Group A the internal iliac artery divides into two major branches, the superior gluteal artery and the common trunk of the inferior gluteal and internal pudendal arteries. In Group B the internal iliac artery divides into a posterior branch with the superior and inferior gluteal arteries, with the internal pudendal artery having an independent origin. In Group C all three main internal iliac branches have independent origin at the same location. In Group D, the superior gluteal and internal pudendal artery have common origin and the inferior gluteal artery arises independently. Besides these three main branches, other important imaging features of the remaining pelvic vasculature were assessed.

Results

We reviewed the branching patterns of the internal iliac arteries of 42 male pelvic sides with angio MR, angio CT and/or digital angiography, using the 4 group Yamaki classification [14].

Twenty-six pelvic sides were classified as Group A (61.9%), 13 as Group B (31%) and 3 as Group C (7.1%) with no cases of Group D found.

In Group A, the superior gluteal artery arises independently and exits the pelvis almost immediately. The common gluteal–pudendal trunk (anterior trunk with the inferior gluteal and pudendal arteries) has a very variable morphology, with high bifurcations near the origin in some cases (thus short common trunk) and low bifurcations with long common trunks in other cases. The two vessels may be somewhat difficult to distinguish because they share a similar trajectory (Fig. 1). In Group B there are usually no difficulties in distinguishing the inferior gluteal and pudendal...
arteries as they have very different origins, apart from each other (Fig. 2). In Group C all branches have independent origins and are easily depicted from each other (Fig. 3).

Distinguishing these three main collateral branches of the internal iliac artery was achieved in every case using the three imaging modalities. The superior gluteal artery (Fig. 4) was the largest branch in all cases with a thick trunk with a very typical trajectory, describing an arch superiority concave, passing under the superior border of the great sacro-sciatic foramen, exiting the pelvis above the pyriformis muscle, dividing shortly after into numerous muscular branches to the superior gluteal region. The inferior gluteal artery (Fig. 5) was the second largest branch visualized, with variable origins regarding the type of internal iliac bifurcation, usually at the level of the upper border of the great sacro-sciatic foramen. Afterwards it follows a trajectory downwards and outwards, exiting the pelvis underneath the superior gluteal artery, on the inferior aspect of the great sacro-sciatic foramen, beneath the pyriformis muscle. It terminates on the inferior aspect of the gluteal region giving off numerous muscular branches. The internal pudendal artery (Fig. 5) was the thinnest collateral in many cases due to extensive atherosclerotic changes. It follows an initial trajectory similar to the inferior gluteal artery (mainly in Group A bifurcations), but shortly after exiting the pelvis in the lower aspect of the great sacro-sciatic foramen, re-enters the pelvis through the lesser sacro-sciatic foramen, crossing the spine of the ischium. Afterwards, it follows a straight trajectory with numerous perineal collateral branches, terminating in the arteries of the penis.

Another prominent artery frequently encountered was the obturator artery (Fig. 6), with variable sizes (sometimes similar to the inferior gluteal artery). It was identified as a collateral branch of the internal iliac artery in 28 cases.
In the remaining 14 cases (33.3%), the obturator artery had an origin from the epigastric artery (from the external iliac artery). When originating from the internal iliac artery, it originated from the anterior common (anterior) gluteal–pudendal trunk in 14 cases (50%), from the posterior (common gluteal) trunk in 3 cases (10.7%), from the internal pudendal artery in 3 cases (10.7%), from the inferior gluteal artery in 3 cases (10.7%), from the superior gluteal artery in 3 cases (10.7%) and directly from the internal iliac artery in 2 cases (7.2%). It follows a distinct trajectory, running forwards, into the obturator foramen exiting the pelvis. Shortly after, it usually divides into two terminal branches that form approximately a 90° angle: an internal and an external muscular branch, for the internal upper thigh.

Accessory pudendal arteries (Fig. 7) were only identified in one pelvic side (2.4%), with an origin in the internal pudendal artery, before exiting the pelvis in the great sacro-sciatic foramen, running downwards and forwards, passing near the base of the bladder, near the upper pole of the prostate, terminating as the dorsal artery of the penis.

Discussion

From a clinical and imaging point of view, the classification of the internal iliac artery by Yamaki according to the different branching patterns seems to be the simplest and most reproducible classification of this complex vascular system [14]. Based on this classification we can provide basic branching patterns that allow easy recognition of the different collateral arteries to the pelvis. However, Yamaki’s study was performed on cadaveric specimens and the corresponding imaging findings using different imaging modalities are lacking.
In this work we found a good correlation between the imaging results and the results reported in the cadaveric studies. It was possible to identify three out of four Groups of the Yamaki classification, with detailed anatomy and imaging findings provided. Group A was the main branching pattern found confirming the results by Yamaki, however, with a lower prevalence in this study (n = 26, 61.9% as opposed to 80% reported by Yamaki). The remaining branching patterns found are considered anatomical variants as they are less frequent. Like the findings by Yamaki, the second most frequent branching pattern was Group B (n = 13, 31%), although with a higher frequency (15% in the study by Yamaki) and the third was Group C (n = 3, 7.1%), with similar frequency (5.3% in the study by Yamaki). We found no cases of Group D as expected, because it is very rare. Yamaki studied 645 pelvic sides and only found one case (0.2%). It would be necessary to perform a larger study with more patients in order to be able to identify this branching pattern. Some of the limitations we found with the Yamaki classification may be due to the fact that this was not a cadaveric study, the population was not Oriental, but European and we only included male individuals.

The classification used is based on the branching patterns of the main internal iliac artery collaterals—the superior and inferior gluteal and the internal pudendal arteries. However, we found another frequently prominent artery arising from the internal iliac artery, the obturator artery. In some individuals this artery may have sizes similar to the inferior and even superior glutteal arteries. Thus, this artery could also be used to classify the branching patterns of the internal iliac artery. However, we found (as previously

**Fig. 3** Comparison between angio MR and angiography of Group C bifurcation of the right side (a, b) and left side (c, d) internal iliac artery. The three main arteries have simultaneous and independent origin. Also note bilateral prominent obturator arteries: a angio MR (3D). b Selective angiography with right anterior oblique projection (35°) and caudal-cranial angulation (10°). c Angio MR (3D). d Selective angiography with left anterior oblique projection (35°) and caudal-cranial angulation (10°). 1 Internal iliac artery common trunk, 2 superior gluteal artery, 3 inferior gluteal artery, 4 internal pudendal artery, 5 obturator artery.
described [5]), that the obturator artery only arises from the internal iliac artery in 2/3 of cases. In the remaining 1/3 it originates from the inferior epigastric artery. These anatomical features and the fact that the artery may have many different origins make it a poor candidate for internal iliac artery classification.

Another important anatomical variation found was the presence of the accessory pudendal artery. However, we only found one case (2.4%) which is inferior to the estimated 4–70% prevalence reported by some authors [8, 12].

There are some limitations to this study. We described the branching patterns of the main collaterals of the internal iliac arteries and did not focus on the remaining arteries of the pelvic internal organs which were considered beyond the scope of this study. It was possible to identify other minor collateral vessels like the vesical and prostatic arteries in some patients arising from the common gluteal–pudendal trunk or the internal pudendal artery. Also the iliolumbar and lateral sacral arteries were frequently detected as collaterals arising from the superior gluteal artery or from the posterior common trunk with the superior and inferior gluteal arteries. However, the small size of these arteries makes them poor candidates for internal iliac artery classification. Future studies regarding the detailed anatomy of these small collaterals are warranted.

In this study we present the main imaging and anatomical patterns of the internal iliac arteries with the use of three different imaging modalities, so that selective identification of individual branches is easier and their radiological findings more conspicuous. Vascular imaging evaluation and anatomical knowledge is essential for any surgical or interventional radiology procedure. Pelvic selective arterial embolization is frequently performed in our institution for symptomatic uterine fibroids and to control bleeding associated with trauma, locally advanced pelvic malignancies or postpartum, as previously described [3, 4, 9–11]. Also, there is a rising interest in male pelvic vascular anatomy as selective prostatic arterial embolization to treat benign prostatic hyperplasia may follow uterine artery embolization for fibroids [1, 7]. However, in order to avoid untargeted embolization and ischaemic complications due to subselective embolization, superselective catheterization is warranted, which can only be achieved with good vascular imaging evaluation and anatomical knowledge.

Digital angiography was the gold standard in this study, being the technique with better resolution, especially when identifying smaller branches or vascular anastomosis. However, it is an invasive procedure and was only used in these patients because pelvic selective arterial embolization was a treatment planned. Using non-invasive imaging
Fig. 5 Inferior gluteal (1) and internal pudendal (2) artery anatomy in Group A internal iliac bifurcations. Comparison between angio CT and angiography. Note the initial close proximity between the inferior gluteal (1) and internal pudendal (2) arteries and the different types of common anterior gluteal–pudendal trunks: a angio CT (3D) of the right side. b Selective angiography with right anterior oblique projection (35°) and caudal-cranial angulation (10°). c Angio CT (3D) of the right side. d Angio CT (3D) of the left side.

Fig. 6 Obturator artery anatomy (arrows). Comparison between angio CT and angiography. Different origin types: a angio CT (3D) of the right side with origin in the common anterior gluteal–pudendal trunk. b Angio CT (3D) of the left side, origin in the common posterior gluteal trunk. c Selective angiography with right anterior oblique projection (35°) and caudal-cranial angulation (10°), origin in the superior gluteal artery. d Angio CT (3D) of the right side, origin in the inferior gluteal artery. e Selective angiography with right anterior oblique projection (35°) and caudal-cranial angulation (10°), origin in the internal pudendal artery. f Selective angiography with right anterior oblique projection (35°) and caudal-cranial angulation (10°), origin in the internal iliac artery. g Angio CT (3D) of the left side, origin in the epigastric artery.
techniques such as angio CT or angio MR before any kind of intervention (digital angiography or surgical procedures) is very useful, guiding the procedure and providing basic vascular maps. For example, 3D reconstructed contrast-enhanced angio MR has been shown to detect most branches of the internal iliac artery being able to be used as a mapping tool of the pelvic arterial tree [9]. However, in our experience, angio CT was able to better depict smaller branches of the internal iliac artery. Also, CT allows depicting blood vessels with or without bone structures that may be used as landmarks. For these reasons we started performing angio MR before digital angiography, but now we prefer to use angio CT instead. Only patients with contraindications for iodine contrast injection perform angio MR. In our institution we always perform angio CT or angio MR before pelvic digital angiography when selective arterial embolization is planned, especially in older and male patients where iliac atherosclerotic lesions may prohibit vascular access. Using angio CT or angio MR beforehand enables us to plan treatment strategies, providing basic anatomical vascular patterns. With the information provided by non-invasive imaging techniques we can plan if we will use unilateral or bilateral femoral approach, the best femoral side puncture to avoid iliac tortuosity or occlusion, the type of catheter and guide-wire used or the best tube angulations.

Conclusion

Angio MR, angio CT and digital angiography are able to detect most branches of the internal iliac artery. Group A was the most frequent internal iliac artery branching pattern. The imaging findings of the main branches of the male internal iliac artery, regarding anatomy and morphology are depicted. Angio CT showed better detailed anatomy than angio MR and digital angiography was considered the gold-standard. Non-invasive vascular imaging with angio MR or angio CT is essential before digital angiography or other vascular intervention, especially in male older patients with atherosclerotic changes, allowing better planning of the procedure.

Conflict of interest

None.

References