Renal vascular evaluation with 64 Multislice Computerized Tomography
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INTRODUCTION
Renal angiography obtained through Multi-slice computerized tomography (MSCT) is becoming a quick non-invasive imaging modality of great clinical usefulness in the study of both the normal vascular anatomy and its variants as well as the arterial and venous pathology and is in many institutions replacing digital angiography\(^1,2\). Knowing the normal vascular anatomy and its variants is critical for pre-surgical evaluation particularly when the surgical techniques are partial or laparoscopic nephrectomy and renal transplantation. The aim of this study is to show several vascular variants both arterial and venous considering that a clear understanding of the anatomy, the use of an adequate study protocol and the understanding of eventual pitfalls allow greater diagnostic efficacy.

MATERIAL AND METHODS
A retrospective analysis was performed of the abdominal-pelvic images acquired between January and June 2007 with the Philips Brilliance 64-slice CT scanner. The study protocol consisted in sequences without contrast agent followed by contrast enhanced images both in the arterial and venous phases. Patientes were administered an intravenous injection of 120 ml of iodine contrast via a dual head pump followed by 60 ml of saline solution at an infusion rate of 3/5 ml/sec using an 18 abocath preferentially placed at the elbow fold vein. The crude data parameters were the following: 3 mm
thickness sections, 1.5 mm increments using a 512 x 512 template. After the images were obtained, every sequence was processed using 0.9 mm thickness sections and 0.4 mm increments to diminish the radiation dose delivered to the patients. The bolus track technique that senses the arrival of the contrast agent at a predetermined height of the aortic lumen was used to achieve an adequate arterial phase. The venous phase was acquired 60 seconds after the arterial phase. The images thus obtained were read in the three orthogonal planes and then processed in the Philips Brilliance 190P workstation for an average of 30 minutes to develop the MIP and volume rendering reconstructions. All patients were given an intramuscular injection of Hioscine butyl-bromide to diminish intestinal peristalsis. In individuals whose complaint was of urological nature oral water was used as contrast agent.

RESULTS

Our retrospective evaluation revealed a total of 26 anatomical variants of the renal vasculature: 16 were arterial (61.5%) and 10 were venous (38.5%), as follows:

**Arterial variants:** 3 bifurcations of the renal artery at pre-hilar level (Figure 1), 4 accessory renal arteries (Fig 2) and 9 polar arteries (Fig.3)

**Venous variants:** 5 multiple renal veins (fig.4); 2 retro-aortic veins (fig.6), and 1 prominent lumbar tributary vein (fig.7)

DISCUSSION

The current significance of the 64-detector MSCT in urological work up is based on the fact that it is the only method capable of evaluating the status of the renal parenchyma, the collector system and vascular anatomy, data of paramount importance in renal donors. Renal angiography using 64 detector MSCT, a non-invasive imaging modality with temporal and spatial high resolution can show the arterial and venous structures of the renal hilus reliably with a diagnostic efficacy equivalent to that of digital
angiography (1). The size, course and number of the anatomical relations of these vessels can be easily visualized in the post processing 3D reconstructions (1,3).

The normal vascular anatomy of the renal artery in the great majority of patients (70 to 75%) consists in a single artery per kidney that arises off the aorta (4,5). Normally, this aortic origin is at the level of the second lumbar vertebra (L2) immediately below the take off of the superior mesenteric artery. Just before the renal hilus, the renal vein runs anterior to the artery and the artery, in turn, runs anterior to the renal pelvis.

The right renal artery has a cephalocaudal course because the right kidney is in a relatively lower position and lies behind the inferior vena cava (IVC). On the other hand, the left renal artery that arises below the right artery has a more horizontal course or slightly upwards direction because the corresponding kidney is in a higher position. Both arteries take a posterior direction to approach the position of the kidneys. Close to the renal hilus the renal artery branches for the first time giving rise to the posterior segmental branch that lies behind the renal pelvis. The main trunk of the artery continues its course until it divides into 4 anterior segmental branches exactly at the hilus, the apical, superior, middle and inferior branches. Both the apical anterior segmental artery as well as the inferior branch supply the anterior and posterior portions of the respective renal poles whilst the superior and middle branches only supply the remaining anterior kidney surface (4,6). These segmental arteries enter the kidney sinus where they ramify into the interlobar arteries. The posterior branches include the interlobar, arcuate and inter-lobular arteries.

The kidney has some avascular planes, one at the hilus and the other one where the artery bifurcates into the anterior and posterior branches, located on the posterior side at one third of the distance between the anterior and posterior surfaces of the kidney. The other avascular planes are found between the polar kidney segments and the posterior
aspect. The avascular planes are of critical importance for surgery as they can be used to perform clean incisions \(^4\).

The renal veins flow in the reverse direction of the renal arteries. 92\% of the population has a single vein per kidney \(^5\). Venous drainage starts at the arcuate veins of the cortex and the interlobar veins. After that, the lobar veins join to form the main renal vein that normally lies anterior to the renal artery at the level of the kidney hilus. The left renal vein is approximately 3 times longer than the right vein (6 - 10 cm vs. 2 - 4 cm) and courses between the aorta and the superior mesenteric artery to finally outflow into the medial side of the IVC. The left vein, in contrast with the right one, receives many tributary branches before it outflows, the adrenal vein in the superior side, the gonadal vein in the inferior side and the lumbar vein located posteriorly \(^1, 5\). This is a particularly important fact when the tributaries are ingurgitated because the left kidney is normally the preferred one to be resected in donors because it is technically simpler to remove and its vein longer \(^1, 5, 7\).

The right renal vein drains into the lateral side of the IVC and receives no tributary branches.

MSCT is capable of demonstrating the renal arterial and venous anatomy with a sensitivity that approaches 100\% \(^1, 8\). The branches are visible up to at least the segmental portion but venous structures smaller than 2mm in diameter are very difficult to assess. In order to achieve their correct interpretation renal veins should be assessed in both phases, arterial and venous taking into account that they usually enhance quickly \(^5\). It is necessary to analyze the crude and the reconstructed data to avoid false positives as a result of the superimposed normal vascular structures located close to the renal hilus \(^1\).
The most frequent renal arterial variants are the *accessory renal arteries* (double, triple or quadruple) that are found in up to one third of the population and are considered as a persistence or remnant of the embryologic lateral splenic artery $^{(5)}$. The accessory renal arteries may be unilateral (30%) or bilateral (10%) $^{(1,9)}$. The hilar accessory renal arteries are usually the same size as the single renal arteries $^{(1)}$. Their origin may vary from aortic to iliac, that is to say, at any level starting from T11 to L4 and in some rare cases they may arise from the thoracic aorta, from the mesenteric arteries or the celiac trunk $^{(1,5)}$. These arteries arrive at the renal hilus and supply the polar regions of the kidneys.

*The polar renal arteries* differ from the *accessory renal arteries* in their caliper, they are smaller. As the accessory arteries, the polar arteries also supply the renal poles but do not reach the hilus.

Another frequent variant is the *pre-hilar arterial bifurcation*, of fundamental importance in renal donors because surgery requires a minimal length of 2 cm in the main renal artery prior to its bifurcation to assure adequate anastomosis.

The more common venous variants are the *multiple renal veins* (double, triple or quadruple) that are seen in about 15% to 30% of the population, more frequently on the right side (approaching 30%). Sometimes the renal vein may divide before it outflows into the IVC $^{(1,5,10)}$. The most frequent anatomic variant on the left side is the *circum-aortic renal vein* (up to 17% of the population) $^{(1,5)}$. In this case the main renal vein bifurcates into a ventral and a dorsal branch (normally the smallest) surrounding the abdominal aorta. On other occasions the *circum-aortic vein* is made up by two completely independent renal veins that arise at hilar level. When a *circumaortic vein* is present, the adrenal tributary normally drains into the anterior branch whilst the gonadal tributary flows into the posterior branch $^{(1,11)}$. 
The *retroaortic renal vein* is more infrequent (3% of the population) than the circumaortic vein. It is characterized by a single left renal vein that pursues its course behind the aorta and later outflows into the low lumbar portion of the IVC at times in the primitive iliac vein.

Correct demonstration of the renal vasculature variants above described is of particular importance in the preoperative work up of patients scheduled for nephrectomy for renal donation particularly taking into account that since 1995 the surgical method of choice is laparoscopy that with its small field of vision cannot visualize such variants thus involving a risk of bleeding caused by inadverted vascular injury.

This risk may be decreased by studying renal donors with MSCT, an angiographic non-invasive imaging modality that has shown to have a diagnostic efficacy similar to that of digital angiography\(^{(1,5,12)}\).

**CONCLUSION**

The study of renal vasculature has become critically important in surgical planning of partial laparoscopic nephrectomies and in renal transplant. This fact provides great significance to the 64-MSCT given the high quality of the reconstructions obtained with a diagnostic efficacy equal to that of digital angiography. It is a quick, non-invasive imaging method that allows in a single session, a complete assessment of the renal condition, the collector system and the vascular structures.

**EPIGRAPHS**
Fig.1. MSCT reconstructions: coronal and oblique coronal volume rendering reconstructions showing the bilateral pre-hilar bifurcation into 2 branches on the right (white arrows) and into four branches to the left (gray arrows).
Fig. 2. a), b). MSCT: Coronal and coronal oblique volume rendering reconstructions showing double bilateral accessory renal arteries (White Arrows) Note the high aortic origin of the right superior renal artery at the level of T12 (gray arrows).

Fig. 3. MSCT: MIP reconstructions (a) and volume rendering reconstruction (b) showing a right inferior polar artery (White Arrows). Note that the vein runs towards the inferior pole without going through the hilus provoking pyelo dilatation.
Fig. 4. MSCT Coronal oblique MIP reconstruction showing triple renal veins on the right (a) and double renal veins on the left (b) (Arrows).

Fig. 5. MSCT: Coronal MIP reconstruction (a) showing the pre-aortic anterior branch (Black arrow) the posterior retroaortic branch and the coronal and axial oblique images (b) revealing the circumaortic vein it its full length (White Arrows)
Fig. 6 MSCT: Coronal oblique MIP reconstructions showing the retroaortic renal vein from the anterior and posterior planes (Arrows) IVC: Inferior vena cava, Ao: Aorta

The ones in (a) are accessory.