

INTRODUCTION

Renal arterial injuries could develop either iatrogenically following urological interventions, mostly: percutaneous nephrolithotomy (PCNL), renal trucut biopsy and percutaneous nephrostomy tube application or traumatically as in (blunt like motor car accidents, or penetrating ones as stab wounds) (*Da Costa, 2016*).

Life threatening hemorrhagic complications could occur in up to 15% of those patients (*Da Costa, 2016*).

Surgical corrections to control bleeding could exacerbate it by release of the tamponade effect of the perirenal hematoma, in addition to the postoperative higher risk of morbidity/mortality and longer hospital stay (*Khan, 2016*).

Trans-catheter arterial embolization is an endovascular approach achieving adequate control of renal hemorrhage. It has recently emerged as an alternative to surgical control of renal arterial injuries since it is minimally invasive, with fewer postoperative complications and shorter hospital stay (*Kim, 2018*).

The role of trans catheter renal artery embolization has presently become more renowned due to the great advancement in embolizing materials such as vascular coils, endovascular glue and the introduction of the microcatheters enabling precise bleeder localization and its superselective catheterization with minimal parenchymal loss (*Kim, 2018*).

Among the commonest angiographically discovered complications following renal arterial injuries are: pseudo-aneurysms, pseudo-aneurysms with arteriovenous fistulae (AVF), AVF without pseudo-aneurysms and contrast extravasation to the pelvicalyceal system (**Lobko, 2016**).

General rules applied for embolic agents choice include: the site of the bleeder whether proximal or distal, size of the injured artery, accessibility of the source of bleeding and ability to spare other non-bleeding arteries, blood flow at the lesion level, vessel safe sacrifice with preservation of the normal renal parenchyma and hemodynamic status of the patient (**Lobko, 2016**).

Broadly speaking vascular metallic coils are used in proximal large bleeder embolization, polyvinyl alcohol (PVA) particles are used in small scarce vascular beds, and glue is used in hemodynamically unstable patients with hemoglobin concentration less than 5 mg/dl or platelet count less than 30,000/ul due to the fact that it is the only embolic agent not depending on the patient's coagulation (**Lobko, 2016**).

Little is known about the side effects of the renal arterial embolization which might result from over devascularization of a large portion of the renal parenchyma, with subsequent loss of function, as well as renin secretion and causal hypertension by the ischemic renal parenchyma (**Khan, 2016**).

AIM OF THE WORK

The aim of this work is to assess the success of the technical methodology and the short term clinical outcome of renal artery embolization in patients with iatrogenic renal arterial injuries in ain shams university hospitals.

GROSS AND RADIOLOGICAL ANATOMY

Gross Anatomy:

The kidneys are bean-shaped structures weighing about (135-150) grams according to the gender being smaller in females. They are about 10-12 cm in length, 5-7 cm in width, and 2-3 cm in thickness (*Klatte, 2015*).

Both kidneys are positioned in the retro-peritoneum, situated on both sides of the spine between the transverse processes of T12-L3 vertebrae. The right kidney is 1-2 cm lower than the left one due to the position of the liver (*Klatte, 2015*).

Their orientation is slightly oblique where the right kidney is nearer to the midline and the upper pole of each kidney lies medial and posterior to the lower pole (*Klatte, 2015*).

The renal relations to other organs vary on each side.

- Anteriorly on the right side, the kidney is covered by the liver and the hepatic colonic flexure whereas the hilum is covered by the head of pancreas and the second part of the duodenum (*Netter, 2014*).

- Anteriorly on the left side, the kidney is covered by the stomach, spleen and splenic colonic flexure whereas the renal hilum is closely related to the splenic vessels and the pancreatic tail (*Netter, 2014*)(*Fig. 1*).

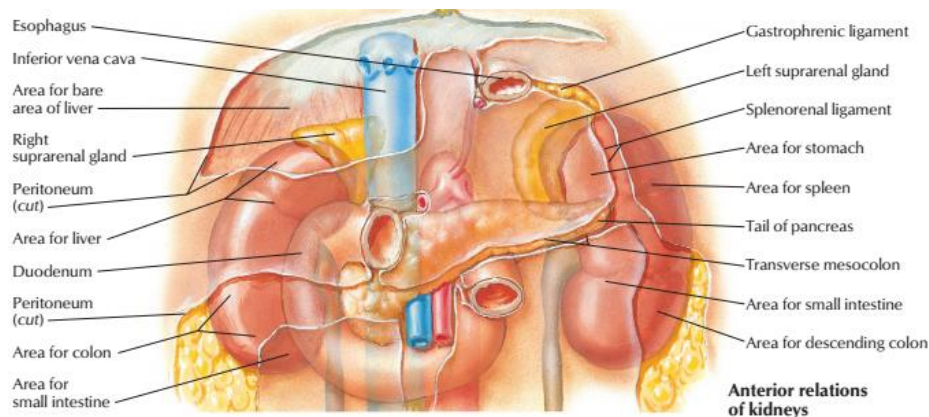


Fig. (1): Image shows anterior relations of the kidney (*Netter, 2014*).

- Posteriorly, both kidneys lie on the quadratus lumborum muscles and the aponeurosis of the transversus abdominus muscles (laterally) and on the psoas muscles (medially) with the diaphragm covering the upper renal poles (*Netter, 2014*) (*Fig. 2*).
- Superiorly, the upper poles of the kidneys are related to the adrenal glands, which lie like caps to the kidneys above the renal hila, especially on the left side (*Netter, 2014*).

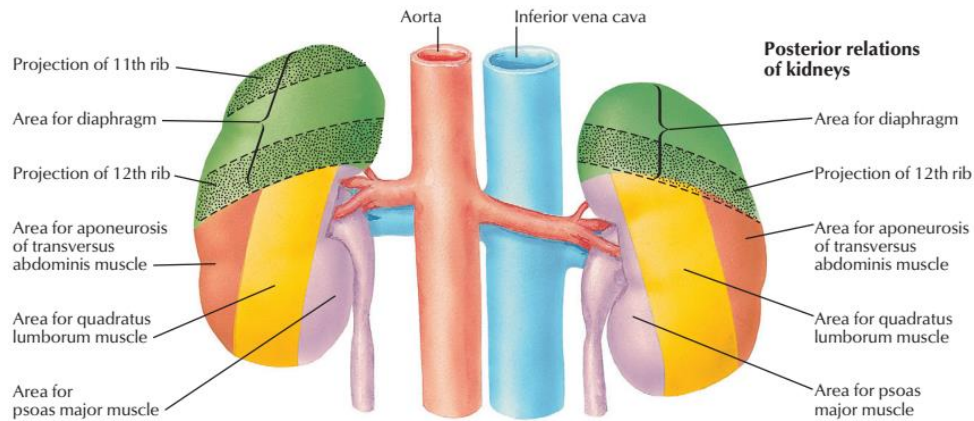


Fig. (2): Image shows posterior relations of the kidney (*Netter, 2014*).

Each kidney along with its adrenal gland is enclosed inside two layers of fat, the inner layer (the perinephric fat) located between the renal fascia and capsule whereas the outer layer (the paranephric fat), located superior to the renal fascia (*Kirkpatrick, 2017*).

The formerly mentioned structures are enclosed inside the Gerota's fascia; whose two layers are fused from all sides except inferiorly (*Kirkpatrick, 2017*).

Normally, the renal hilum exhibits a slight anterior rotation and classically contains the following structures arranged anteriorly to posteriorly: a single renal vein, a single renal artery and the renal pelvis (*Khosla, 2016*).

Arterial supply

Origin and normal variants

A single renal artery arises bilaterally from the lateral aspect of the abdominal aorta just inferior to the origin of the superior mesenteric artery (at the level of L2 vertebra) in 75% of cases (**Macchi, 2018**) (**Fig 3**).

In 25% of cases, there are 2 or more arteries supplying one kidney, which can be unilateral or bilateral (**Macchi, 2018**).

Two separate entities of arterial variants should be distinguished from each other: an accessory artery which is any supernumerary artery that reaches the renal hilum and an aberrant artery which does not enter the renal hilum (**Animaw, 2018**).

Accessory renal arteries mainly arise from the abdominal aorta. Upper polar accessory arteries are usually smaller in caliber than the lower polar ones (**Animaw, 2018**).

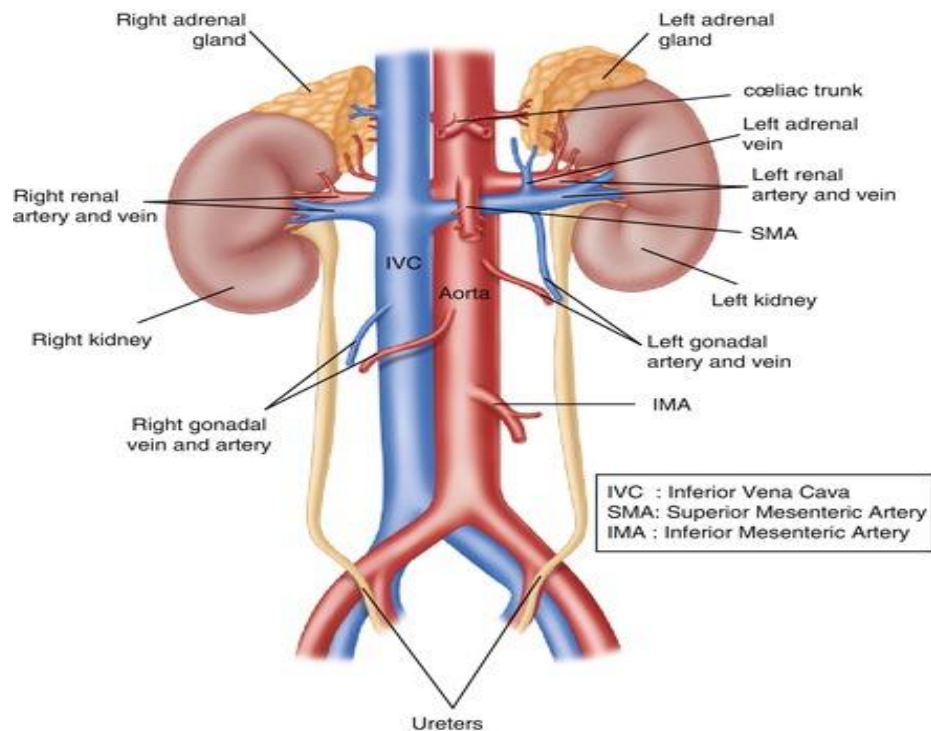


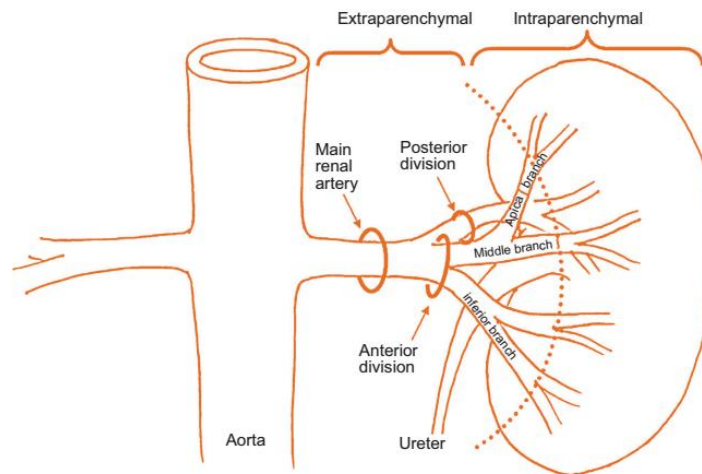
Fig. (3): Image shows vascular supply of the kidney (Netter, 2014).

Course:

The right renal artery is lower than the left, usually having a long downward course towards the right kidney passing posterior to the inferior vena cava (IVC) and is usually postero-superior to the right renal veins (Majos, 2017).

Branches

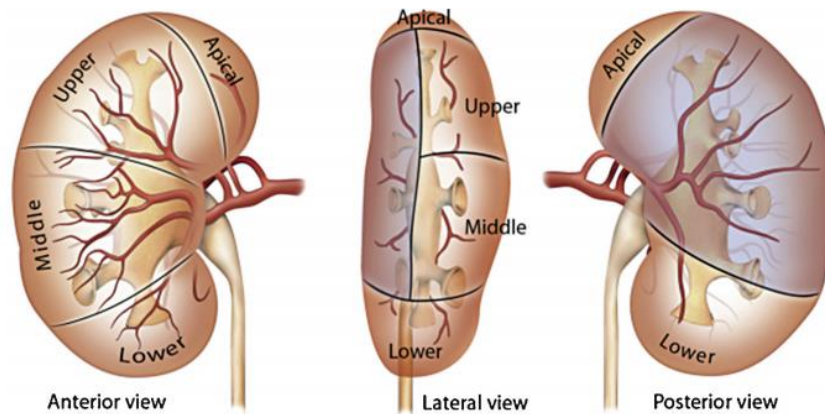
Each renal artery gives off few small branches in its proximal course. They include: inferior adrenal artery, ureteric artery and capsular artery, the latter anastomosing with the intra parenchymal renal arteries (Majos, 2017).



A) Drawing showing Graves's anatomic classification for segmental renal arteries (*Animaw, 2018*).

More distally, the renal artery is subdivided-outside the renal hilum-into anterior and posterior divisions, carrying 75% and 25% of the renal arterial blood supply respectively (*Majos, 2017*).

The aforementioned arterial divisions are further divided - according to Graves' classification- into five segmental branches. The anterior division ends in: apical, upper, middle, and lower segmental arteries whereas the posterior division ends in a posterior segmental artery, all of which are end arteries which do not provide sufficient collateralization (*Animaw, 2018*) (Fig. 4-A/B).



B) Drawing showing Graves's anatomic classification for segmental renal arteries (*Animaw, 2018*).

Fig. (4): Renal arterial system anatomy.

Variations from Graves' initial classification occur, more commonly in the lower segmental artery, which may arise from the main renal artery, its anterior division, its upper segmental artery, or as an accessory artery from the abdominal aorta (*Animaw, 2018*).

Segmental arteries branch at the level of the fornix to form the interlobar arteries, which continue in the interlobar septae between the pyramids. Each interlobar artery branches at the corticomedullary junction into 5-7 arcuate arteries, which then branch into interlobular arteries giving supply to the afferent glomerular arteries and capsular perforating arteries (*Animaw, 2018*) (Fig. 5).

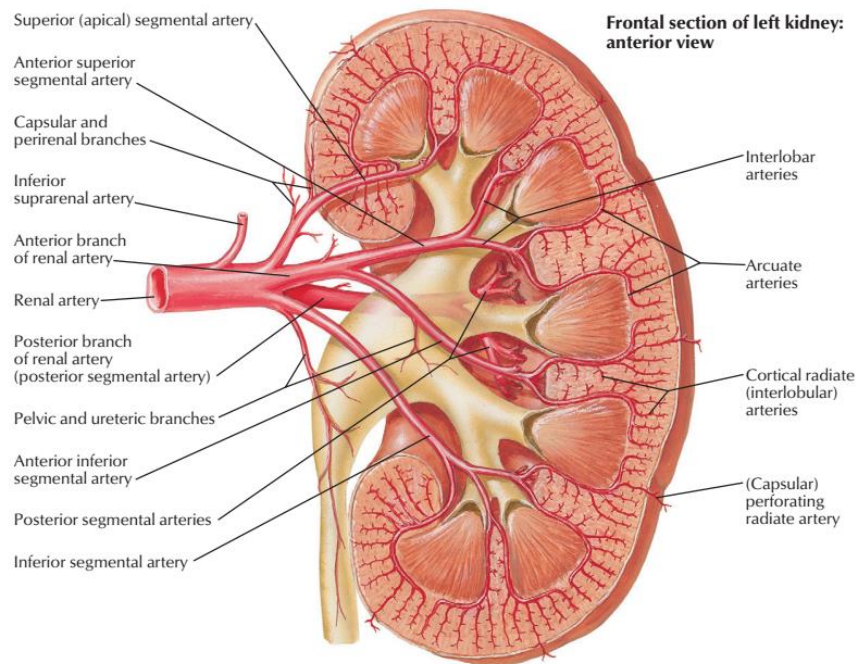


Fig. (5): Drawing showing branching of segmental renal arteries
(Animaw, 2018).

Venous system:

The peritubular capillary venous plexus drains into the arcuate veins through the venae rectae which in turn drain into the interlobular veins forming the arcuate veins leading to the interlobar veins. The latter form 2-3 trunks that ultimately unite into the renal vein. In almost 60% of cases, a retropelvic vein partially drains the posterior aspect of the kidney (Çinar, 2016) (Fig. 6).

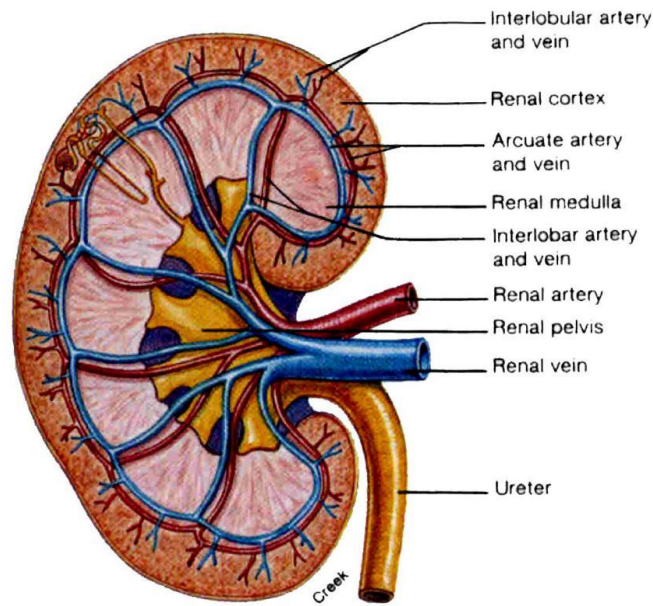


Fig. (6): Image showing renal venous drainage (*Khosla, 2016*).

The right renal vein drains directly into the IVC. It often has no tributaries; yet in rare cases, it drains the right gonadal vein drains into it. Duplicate veins are found in 20% of cases (*Çınar, 2016*).

The left renal vein is approximately 2-3 times longer than the right renal vein draining into the IVC while passing anterior to the aorta. Its tributaries include: left gonadal vein, left adrenal vein, inferior phrenic veins, the 1st or 2nd lumbar veins, and paravertebral veins. In 30% of cases, a retroaortic or circumaortic left renal vein may be present (*Çınar, 2016*).

Radiological Anatomy:

I) Ultrasonography (US)

***B mode**

On longitudinal scans, the kidney appears bean-shaped with an average of 9-12 cm in length and 4-5 cm in width (with up to 2 cm difference between both kidneys). On transverse scans, the kidney appears C-shaped (*Granata, 2017*).

It is surrounded by a bright echogenicity that is attributed to Gerota's fascia and perinephric fat (*Granata, 2017*).

The kidney is divided into an outer parenchyma and an inner sinus. The parenchyma is hypoechoic to the hepatic parenchyma, while the sinus appears hyperechoic containing calyces, renal pelvis and renal sinus fat. The medullary pyramids appear hypoechoic between them (*Valiente, 2016*) (**Fig. 7**).

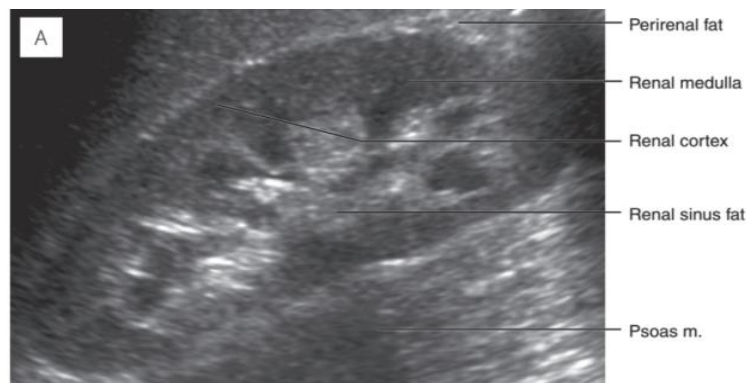


Fig. (7): A longitudinal scan ultrasound image in a right normal kidney (*Ficarra, 2017*).

***Doppler**

Doppler ultrasonography can detect both renal macroscopic and microscopic vascular abnormalities through the detection of vascular impedance at different sites of the renal parenchyma (**Weinberg, 2014**).

The renal arteries are clearly visualized in B Mode using an anterior subcostal approach yet it is perpendicular to the ultrasound beam making it unsuitable for Doppler assessment. Thus an oblique approach is used with angling towards the patient's other side, achieving an acceptable Doppler angle of 60 degrees (**Weinberg, 2014**).

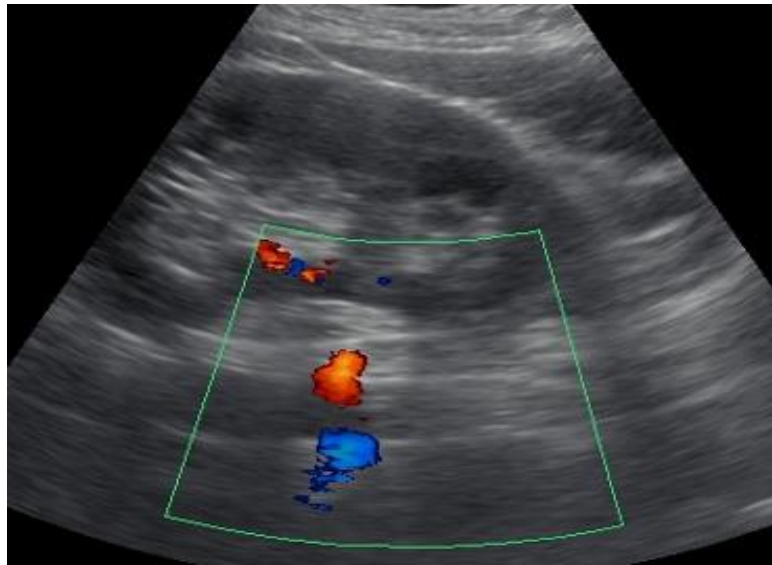


Fig. (8): Showing origin of both renal arteries in an oblique longitudinal approach. Red is towards the probe and blue is away from the probe (**Lobko, 2016**).

When the origin of the renal arteries is imaged in this oblique longitudinal section from the right side, the right renal artery passes directly towards the transducer from the aorta, while the left renal artery is directed away from the transducer (**Fig. 8**) (*Legrand, 2015*).

The normal waveform of the main renal artery shows a low-resistance pattern similar to all the parenchymal organs of the body in the form of rapid upstroke in systole with low resistance waveform and continuous forward flow throughout the cardiac cycle with peak systolic velocity (PSV) in the main renal artery and its branches less than 120 cm/s (*Legrand, 2015*) (**Fig. 9**).



Fig. (9): Showing normal waveform of the main renal artery (*Lobko, 2016*).

II) Unenhanced Computed Tomography (CT)

CT scan provides detailed information owing to its high spatial resolution in the evaluation of masses, stones, pyelonephritis and traumatic injury to the kidney (*Tasian et al., 2014*).