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Original Research Article

Multidetector computed tomographic urography for evaluation of vascular and ureteric anomalies associated with ectopic kidneys

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ABSTRACT

Background: The purpose of this study is to evaluate the vascular and ureteric anomalies associated with ectopic kidneys with multidetector computed tomography (MDCT).
Methods: The 40 patients with pre-diagnosed ectopic kidney undergoing MDCT urography (Contrast study) and KUB (Plain study) were included in this cross-sectional observational study. The location and number of bilateral kidneys were assessed. The number and origin of the renal arteries and renal veins were noted. Their relationship with each other and possible complications in surgical handling analysed. Data collected was analysed using descriptive and inferential statistics.
Results: The renal artery originated from suprarenal aorta in 2 cases, normal origin in 10 cases, infrarenal aorta in 12 cases, aortic bifurcation in 19 cases, common iliac artery in 6 cases and iliac artery bifurcation in 2 cases. The renal vein was of normal origin in 8 cases, originated from infrarenal inferior vena cava (IVC) in 16 cases, IVC bifurcation in 14 cases, common iliac vein in 9 cases, internal iliac vein in 2 cases and external iliac vein in 1 case. There was a significant correlation between the level of ectopic kidneys (abdominal, iliac and pelvis) and level of origin of arteries ($p<0.001$) and veins ($p<0.001$). In addition, significant correlation was found between the origins of arteries and veins of ectopic kidneys ($p<0.001$).
Conclusions: A knowledge of the possible variations in renal vasculature and ureter associated with ectopic kidneys can play a key role in preventing iatrogenic hemorrhage during surgery.

Keywords: Ectopic kidney, MDCT urography, Vascular anomaly

INTRODUCTION

The human kidneys are retroperitoneal organs and are placed in the lumbar region, with the upper pole of left kidney at the level of T11 vertebra, whereas the upper pole of right kidney lies at a slightly lower level, at the level of the T11-T12 intercostal space. The kidneys first lie in the pelvic cavity developmentally, with the hilum being directed anteriorly.[1] During the intra-uterine period they migrate to the lumbar region with the effect of the abdominal wall growth and also rotate medially during migration to the renal fossa. Simple renal ectopia occurs when during embryogenesis, one kidney or both kidneys, remain in pelvis or any other location and does not ascend to the renal fossa. Crossed renal ectopia occurs if a kidney crosses over the midline and is situated contralaterally to its usual location.[2]

While ascending through the pelvis, the regional arteries which are close to the kidneys (the lateral splanchnic branches of the internal and the common iliac arteries) provide nutrition.[1-3] They receive new branches from vessels (iliac and aorta) near them. After reaching the highest point, the former branches degenerate, and they receive new branches from the aorta. More than one accessory and polar arteries may arise, if those vessels do not degenerate in the ectopic kidney.[3] Various combinations of abnormal vessels can occur, most

derived from the distal aorta/IVC, aortic/IVC bifurcation, and iliac vessels.[2] Multiple anomalies can be seen at the same time including ureteral anomalies like duplex collecting system, bifid ureters or retrocaval ureters.[3]

To reduce surgical morbidity and mortality, it is important for preoperative detection of ectopic renal vascular and ureteric anomalies.[4] These anomalies, especially the vessel anomalies, can contribute to complications during interventional procedures and surgeries.[2] The variations of the vessels seen in ectopic kidneys are more diverse than those of the normally located kidneys, causing iatrogenic bleeding frequently during surgery.[4] Therefore, knowledge of the possibility of these anatomical variations will be very helpful to the nephrologists and clinicians in making a correct diagnosis and preventing complications during interventional procedures, urological surgeries and renal transplantation.[5]

METHODS

This cross-sectional observational study was conducted in the department of radio-diagnosis, RajaRajeswari medical college and hospital during the period September 2020 to June 2022. After obtaining clearance and approval from the institutional ethics committee and keeping in accordance with the Helsinki declaration, patients were screened and those who fulfilled the inclusion and exclusion criteria were enrolled in the study. A written informed consent was obtained from these patients. All patients referred to the department of radio-diagnosis for MDCT urography (Contrast study), MDCT KUB (Plain study) and who gives history of previously diagnosed ectopic kidney were included in the study irrespective of age and sex. Hemodynamically unstable patients were excluded from the study. Demographic data (age, gender, address, occupation) and a brief medical history was taken in a pre-structured proforma. 40 patients were evaluated with Seimens Somatom perspective 128 slice MDCT scanner. Corticomedullary phase is used to better delineate the vascular anatomy and delayed phase is used for ureteric evaluation.

Evaluation of CT images

A single experienced radiologist evaluated all the 40 scans. Multiplanar reconstruction images were analyzed with axial, sagittal and coronal images studied together. The location and type of the ectopic kidney was studied. Based on the location of the renal hilum, ectopic kidneys were classified as: pelvic, iliac, and abdominal. Kidneys located below the aortic bifurcation and iliopectineal line were classified as pelvic, those located above the iliac crest and below L2 were classified as abdominal, and those in the iliac fossa near the sacral promontory were classified as iliac. The number and origin of the renal arteries and renal veins were noted and classified as 1. Suprarenal aorta/ inferior vena cava (IVC), 2. Normal origin, 3. Infrarenal aorta/IVC, 4. Aortic/ IVC bifurcation, 5. Common iliac artery/vein, 6. Iliac bifurcation, 7. Internal iliac artery/vein, 8. External iliac artery/vein. Their relationship between level of ectopic kidney and level of vascular origin was analysed.

Statistical analysis

Data collected was analysed using descriptive and inferential statistics and the software used for analysis was MS excel spreadsheet and statistical package for social sciences (SPSS) version 26.0.

RESULTS

The 40 cases with ectopic kidneys were evaluated. The mean age of the patients was 56.2±17.4 (Range 11 to 87 years). There were 23 males (57.5%) and 17 females (42.5%). The left kidney was ectopic in 23 cases (57.5%), right kidney was ectopic in 16 cases (40%) and both the kidneys were ectopic in 1 case (2.5%). Based on the location of the ectopic kidney, 9 (22.5%) were in the abdomen, 29 (72.5%) were in the ilium and 2 (5%) in the pelvis. 32 (80%) of the ectopic kidneys were ipsilateral, 5 (12.5%) were cross ectopic and 3 (7.5%) were cross-fused ectopic.

The 34 cases (85%) had one renal artery, 3 cases (7.5%) had two renal arteries, 2 cases (5%) had three renal arteries and 1 case (2.5%) had five renal arteries. The 32 cases (80%) had one renal vein, 6 cases (15%) had two renal veins and 2 cases (5%) had three renal veins. Based on the origin of the vascular structures, the renal artery originated from the suprarenal aorta in 2 cases, normal origin in 10 cases, infrarenal aorta in 12 cases, aortic bifurcation in 19 cases, common iliac artery in 6 cases and iliac artery bifurcation in 2 cases. The renal vein was of normal origin in 8 cases, originated from infrarenal IVC in 16 cases, IVC bifurcation in 14 cases, common iliac vein in 9 cases, internal iliac vein in 2 cases and external iliac vein in 1 case. The origins of arteries and veins of ectopic kidneys, by ectopic kidney location, are shown in Table 1.

Table 1: The origin of the arteries and veins of ectopic kidneys according to ectopic kidney location.

Origin	Abdominal, n (%)		Iliac, n (%)		Pelvic, n (%)	
	Artery	Vein	Artery	Vein	Artery	Vein
Suprarenal aorta/ IVC	2 (9.52)	0	0	0	0	0
Normal	9 (42.86)	6 (33.33)	1 (5)	2 (8.69)	0	0
Infrarenal aorta/ IVC	6 (28.57)	7 (38.89)	4 (20)	7 (30.43)	2 (20)	2 (22.22)
Aortic/ IVC bifurcation	3 (14.29)	3 (16.67)	11 (55)	9 (39.13)	5 (50)	2 (22.22)

Continued.

Origin	Abdominal, n (%)		Iliac, n (%)		Pelvic, n (%)	
	Artery	Vein	Artery	Vein	Artery	Vein
Common iliac artery/ vein	1 (4.76)	2 (11.11)	4 (20)	5 (21.74)	1 (10)	2 (22.22)
Iliac bifurcation	0	0	0	0	2 (20)	0
Internal iliac artery/ vein	0	0	0	0	0	2 (22.22)
External iliac artery/ vein	0	0	0	0	0	1 (11.11)
Total	21 (100)	18 (100)	20 (100)	23 (100)	10 (100)	9 (100)

Figure 1: MDCT urography image of a 42-year-old male patient with left ectopic kidney.
The ectopic kidney is supplied by the left renal artery originating from the the infrarenal aorta and left renal vein originating from the infrarenal inferior vena cava.

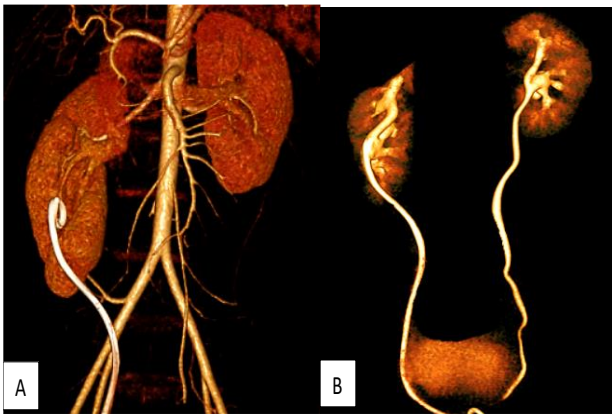

Figure 2: MDCT urography image of a 20-year-old female patient with duplex malrotated right kidney; (A) the duplex right kidney is supplied by two right arteries and two renal veins. Upper pole moiety is supplied by renal artery and renal vein coming from the aorta and inferior vena cava respectively. The lower pole moiety is supplied by renal artery and renal vein coming from right common iliac artery and vein respectively; (B) the duplex right kidney is drained by a single ureter.

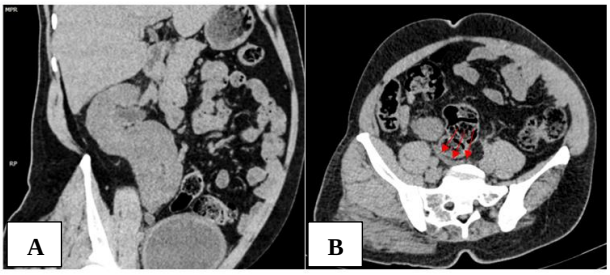

Figure 3: MDCT KUB curved planar reformation image of a 35-year-old female patient with crossed fused renal ectopia. Left ectopic kidney is seen to the right of midline and (A) used to the lower pole of the right kidney; (B) the ectopic kidney's ureter crosses the midline from right to left and enters the bladder on the opposite side.

There was a significant correlation between the level of ectopic kidneys (abdominal, iliac and pelvis) and level of origin of arteries ($p<0.001$, $r=0.630$) and veins ($p<0.001$, $r=0.440$). In addition, a significant correlation was found between the origins of arteries and veins of ectopic kidneys ($p<0.001$, $r=0.588$).

Evaluation of the associated ureteric anomalies showed that there was pelviureteric junction obstruction leading to hydronephrosis in 2 ectopic kidneys and partial double collecting system in 3 cases.

DISCUSSION

There are several studies in literature examining the renal vascular variation of normally located kidneys. A few autopsy based case reports on vascular variations in ectopic kidney.[6-7] Ectopic kidneys have a reported frequency of 1:500 to 1:1100.[7,8] There is no gender predilection. A slightly higher propensity is present for the left side over right side. In our study, there was a slight male preponderance (57.5%). The left kidney was more commonly involved than right kidney (57.5%).

The embryonic kidney ascends from its location in the pelvis between 6th to 9th week as the caudal end of the embryo elongates and straightens. Malascent can occur due to vascular, ureteric and metanephric factors and can result in pelvic ectopic kidney. During the 8th week, renal blood supply shifts from external and internal iliac vessels to the aorta. If the aortic blood supply is not acquired normally or there is an associated abnormality

of the spine, then cephalic migration of the fetal kidney will not occur. This condition will result in renal ectopy or abnormal location of the kidney.[9] As the kidneys acquire a lumbar position, the inferior branches disappear. Persistence of inferior branches may result in multiple renal arteries and veins.[10,11] Ectopic kidneys showed variation in the origin, number, size of renal arteries and veins depending on the site of arrest of ascent during development. The usual site of origin of the vessels supplying the ectopic kidney is the nearest large vessels such as iliac vessels.[7] In our study, 6 cases (15%) of ectopic kidney had multiple renal arteries and 8 cases (20%) had multiple renal veins. It was also seen that, all cases with single renal artery had single renal vein and multiple renal arteries had multiple renal veins. In addition, a significant correlation was found between the origins of arteries and veins of ectopic kidneys ($p<0.001$, $r=0.588$).

Erdoğan et al retrospectively reviewed the origin of the vascular structures in ectopic kidneys with MDCT.[4] The renal artery originated from the suprarenal aorta in 1 case, normal origin in 13 cases, the infrarenal aorta in 36 cases, aortic bifurcation in 50 cases, the common iliac artery in 17 cases, and the iliac artery bifurcation in 2 cases. The renal vein was of normal origin in 19 cases, originated from the infrarenal IVC in 44 cases, IVC bifurcation in 36 cases, the common iliac vein in 23 cases, the internal iliac vein in 1 case, and the external iliac vein in 1 case.

Gokalp et al conducted a case report of a 67-year-old female patient who underwent MRI contrast angiography revealing two different ectopic kidneys, one of which was in the middle of two iliac arteries in the pelvic region and the other localized at a higher spot adjacent to left main iliac artery and aorta.[3] Left kidney had an accessory artery originating from the proximal of the left main iliac artery of left kidney, and 5 polar (capsular) arteries. The mid-level kidney had a renal artery which was originating from the iliac artery with findings of early branching. Mid-level kidney had 2 renal arteries and left vein was joining with left renal artery and opening to vena cava inferior at a low level.

Kulkarni et al conducted a case report of a 55-year-old formalin fixed male cadaver.[1]

The kidneys with renal vessels were neatly dissected and photographs were taken. Bilateral multiple renal vascular variations with a unilateral right ectopic kidney were noticed. The right kidney presented 5 renal arteries and the left kidney presented 2 renal arteries. Also, there were triple right renal veins, in which one was the main renal vein and the remaining were accessory whereas, on the left side, there were 2 renal veins in which one was the main renal vein and the other was the accessory retro aortic left renal vein.

The results of our study, strongly parallels the findings of the previously conducted studies in terms of the origin of arteries and veins in ectopic kidneys. One of the limitations of our study is the evaluation of MDCT images by a single radiologist. Thus, the interobserver variability could not be assessed.

CONCLUSION

Our study shows that majority of ectopic kidneys are associated with vascular and ureteric anomalies. A sound knowledge of these variations and an anticipatory imaging in suspected cases can play a key role in preventing iatrogenic hemorrhage during surgery in patients undergoing renal surgery or transplantation.

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