

CASE REPORT

Ectopic kidney with malrotation and bilateral multiple arteries diagnosed using CT angiography

DELIA ELENA ZĂHOI¹⁾, G. MICLĂUŞ²⁾, AURORA ALEXA³⁾,
DORINA SZTIKA¹⁾, AGNETA MARIA PUSZTAI¹⁾,
MIOARA FARCA URECHE¹⁾

¹⁾*Department of Anatomy and Embryology,
"Victor Babeş" University of Medicine and Pharmacy, Timisoara*

²⁾*Neuromed Diagnostic Imaging Centre,
Timisoara*

³⁾*Department of Histology,
"Victor Babeş" University of Medicine and Pharmacy, Timisoara*

Abstract

Right renal ectopia with malrotation was seen on a CT angiography in a 64-year-old male patient. Bilateral triple renal arteries were also revealed: one main (superior) renal artery and two accessory arteries (middle and inferior), all originating in the abdominal aorta. The renal arteries are disposed symmetrically. The main arteries and the accessory ones are of equal caliber. Simple renal ectopia is a congenital malformation with an incidence of 1–2 cases in 1000 births; of these, only one of 10 cases is diagnosed. Like our case, many such cases are diagnosed by accident, during investigations of causes that have no connection with renal ectopia. Variations in kidney position and renal vascular variants are very important clinically, for both the complications they may generate and the technical difficulties of certain surgical interventions. CT angiography is a minimally invasive method that allows the identification of malformations or anatomic variations, providing accurate information on position, size and anatomic ratios, which are very useful in diagnosing and treating various affections.

Keywords: ectopic kidney, malrotation, supernumerary bilateral arteries, CT angiography.

■ Introduction

Normally, the kidneys are retroperitoneal, located in the lumbar diaphragm fossae. The upper extremity of the left kidney extends to T₁₁ vertebra, while the upper extremity of the right kidney reaches only the T₁₁–T₁₂ intercostal space [1]. The lower left kidney is 4–5 cm above the iliac crest, while the lower right kidney is 2.5–3 cm above it, at the level of vertebrae L₂–L₃ [2]. Kidneys are susceptible to a great morphological variety – number, position, shape, size, rotation and especially vascularization [3].

Unilateral renal ectopia is most frequent (1:1000–1:300 births), but as it lacks specific symptoms, it can be discovered during unrelated investigations. Normally, the kidney develops in the pelvis and reaches its' final position during the 9th week. An ectopic kidney, more frequent in males, can be found in the pelvis, abdomen or even thorax. There is a strong correlation between renal ascension and vascularization. Any anomaly in the renal arteries' origins can stop the ascension and cause ectopia or rotation anomalies. Renal ectopia is associated with anomalies in renal vessels [4]. The presence of multiple renal arteries is the most frequent variant, with a 20–30% occurrence rate, depending on gender and race.

The increase in renal transplants, vascular reconstruction and other urologic procedures requires a detailed

knowledge of the renal morphological variants and their clinical significance. CT angiography represents an important investigation method in patient evaluation.

■ Patient and Methods

The CT angiography was conducted by Neuromed Diagnostic Imaging Centre Timisoara, using a Siemens Somatom Sensation 64.

The patient was injected with contrast material using a dual-head syringe, which enables the contrast material bolus to be followed by saline, in order to keep the bolus, as one mass, at a rate of injection was 4 mL/sec. A test bolus was used to determine the contrast material's pick in the abdominal aorta. The scan was made between the diaphragm and the pubic symphysis, in a single breath hold.

The images were obtained with a scan protocol for abdominal angiography, acquiring 64×0.6 mm with each rotation; the primary data processing was made through 1.5 and 5 mm reconstructions, with an algorithm dedicated to angiographic studies. After completing the primary reconstruction, the images were transferred to the post-processing station for 3D reconstruction, using three methods.

Firstly, 3D MIP (*Maximum Intensity Projection*) with a 5 mm slice thickness which, when the surrounding structures are hidden, enables good views of the

vascular system. Secondly, curved 3D MIP, to follow the entire vascular tract and thirdly, VRT (*Volume Rendering Technique*) reconstructions, which allows a three-dimensional view of anatomical structures, relative positions and vascular pathology.

Results

The case presented below is part of an interdisciplinary study on renal vascular variability. First location, position and dimensions of the right kidney were analyzed compared to the contralateral one. Next, the arterial vascularization of the two kidneys was examined: the origin of arteries, their tract and way of entering the parenchyma. Then the arterial length and diameter and the distances between the levels of origin were measured.

In our case, the upper pole of the right kidney is located at the level of L₂–L₃ intervertebral space, and the inferior pole extends to the L₄–L₅ intervertebral space. The right kidney is 10.92 cm long and 5.13 cm wide and is disposed transversely, with a slight diagonal inferior and medial position. Thus, the anterior face of the kidney is oriented upwards and the hilum is superomedial. Because of malrotation, the upper pole is 2.6 cm laterally to the spinal cord, while the lower pole covers about 1 cm of the L₄ vertebra (Figures 1 and 2).

Three arteries vascularize the right kidney; they are named after their location: one right superior (main) renal artery and two accessory arteries, middle and inferior.

The right superior renal artery (RSRA) originates in the lateral side of the aorta, at the level of L₁ vertebral body. It is 10 cm long and 0.5 cm in diameter, with a tortuous, oblique descending tract. Near the hilum it divides into three branches (two anterior and one posterior), all of them penetrating the renal parenchyma through the hilum. The right middle renal (RMRA) artery also originates in the lateral side of the aorta, at the level of L₃ vertebra, 6.9 cm lower than the origin of the superior renal artery. It is 4.3 cm long and 0.3 cm in diameter. Its tract is almost horizontal initially, but becomes ascending. Halfway between its origin and the point of entry, the right middle renal artery changes its orientation to a right angle and descends to the inferior extremity of the renal hilum, where it enters the parenchyma. The right inferior renal artery (RIRA) is the only branch originating in the anterior side of the aorta, 2.8 cm lower than the origin of the middle renal artery, at the level of L₄ vertebra. It is 6.2 cm long and has an oblique descending tract. It enters the renal parenchyma at the inferior pole. It is also 0.3 cm in diameter (Figure 3).

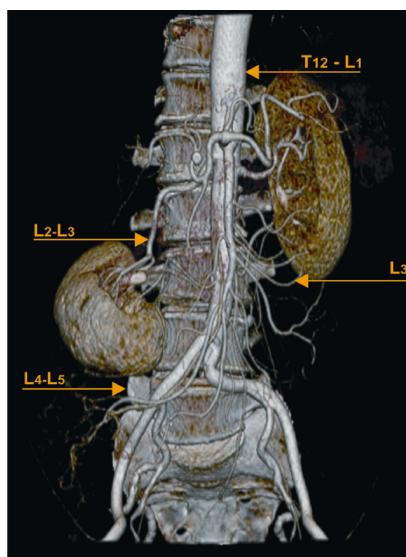


Figure 1 – Kidney position relative to spine. Anterior view. VRT reconstruction.



Figure 2 – Position of the right kidney. Antero-lateral view. VRT reconstruction.

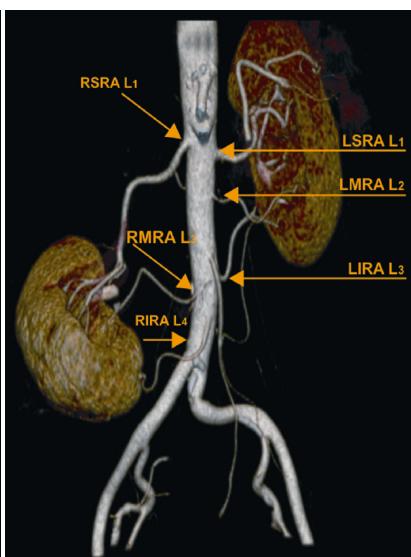


Figure 3 – Origin levels of the renal arteries. Anterior view. VRT reconstruction.

The left kidney has a normal position: its upper pole extends to the T₁₂ vertebral body, and its inferior pole is located at the middle section of L₃ vertebral body. It is 12 cm long and 4.98 cm wide.

The left kidney is also vascularized by three arteries. The left superior (main) renal artery (LSRA) originates in the lateral side of the aorta, at the level of L₁ vertebral body. It has a 4 cm sinuous tract and a diameter of 0.3 cm and it is slightly ascending. The left middle renal artery (LMRA) originates at 1.97 cm lower than the main artery, at the L₂ vertebral body. Its tract is horizontal initially then it descends, describing a concave

upward curve over the anterior face of the left inferior renal artery. Then it changes its tract again and ascends to the inferior part of the renal hilum, entering the parenchyma. It is 6.2 cm long and 0.3 cm in diameter. The left inferior renal artery (LIRA) originates in the lateral part of the abdominal aorta, at the level of L₃ vertebral body, 3.35 cm lower than the right middle renal artery. It is 4.2 cm long and 0.3 cm in diameter and has an ascending, slightly tortuous tract, up to where it crosses the right middle artery. Then its tract becomes horizontal and enters the parenchyma through the inferior pole, near the hilum (Figures 4 and 5).

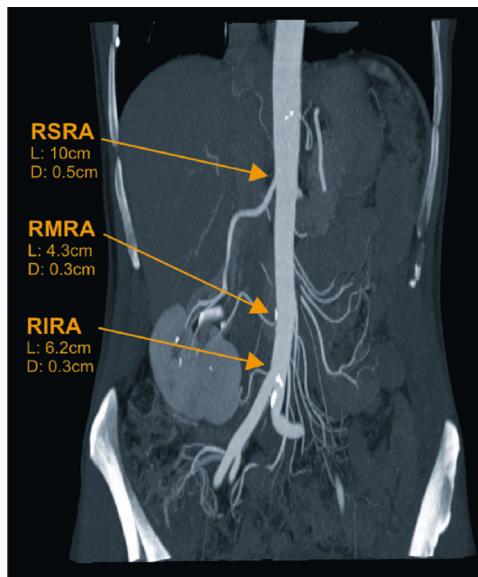


Figure 4 – Dimensions of the right renal arteries. MIP reconstruction.

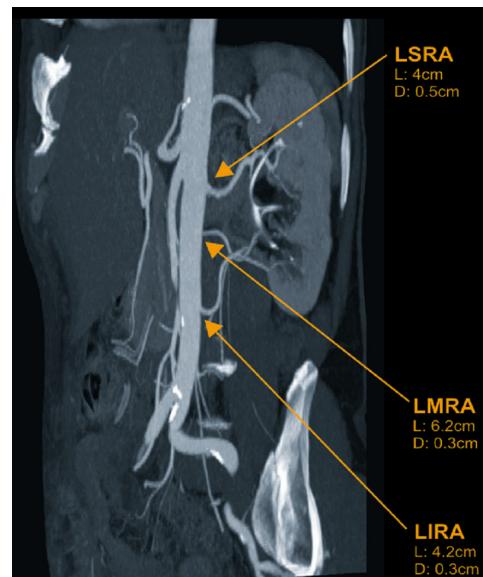


Figure 5 – Dimensions of the left renal arteries. MIP reconstruction.

Discussion

There are two divergent opinions concerning the definite position of the kidneys in anatomical literature. According to the first, the kidney ascends in the retroperitoneal space during precocious ontogenetic development. The renal rudiment occurs in the pelvic region, at the level of L₂-L₃ vertebrae, with the dorsal convex border and the ventral hilum touching the abdominal wall. To place itself in the definite position, the kidney undergoes a process of ascension and rotation. Between the 6th and the 9th week, the kidney ascends to the lumbar region, along the dorsal aorta. The exact mechanism is unknown. The role of an inductive substance secreted by the developing kidney is invoked.

The second opinion says that the kidney undergoes a pseudoascension caused by the fast development of the caudal extremity of the fetus [5-7].

The factors that may interfere with the renal development are teratogenic agents, genetic factors, chromosomal anomalies, disorders in the fusion mechanism of the ureteric bud and the metanephrogenic blastema, medicines ingested by the mother [8]. There are, however, many idiopathic cases [9, 10]. If the intervention of these factors takes place after the two kidneys have separated completely, simple ectopia occurs. The ectopic kidney can be located in the pelvis, in the abdomen or, rarely, in the thorax (0.3%) and can be unilateral or bilateral. The most frequent cases of renal ectopia described in the literature of the field occur in male patients and are located on the right side of the pelvis [11, 12]. Generally, an ectopic kidney is smaller, of irregular shape and variable rotation and is vascularized by multiple arteries with various levels of origin.

The kidney discussed in our cases has normal shape and size. Its position suggests that the factor(s) that affected the renal ascension interfered towards the end of the process, when the kidney was close to its final position. These factors also affected the rotation process.

During ascension, each kidney is vascularized by neighboring arterial branches initially originating in the external and internal iliac arteries and, starting with the eighth week, by branches originating directly in the aorta [13]. These branches do not extend with the kidney ascension, but regress and are replaced by new ones with higher origins. The definitive renal arteries will originate in the upper lumbar region. Consequently, there is a good correlation between the kidney ascension and the level of origin of the renal arteries; any anomaly in renal artery development may delay kidney migration, leading to ectopia [14]. The presence of too many arteries for the apical segment can be explained by a slower than usual process of cranial-caudal degeneration, when mesonephrotic branches persist. Inferior arteries may develop through a delayed process (in the inferior lumbar region) or ascend with the kidney.

A particularity of our case is the vascularization through three pairs of renal arteries disposed symmetrically, all originating in the abdominal aorta. The main (superior) renal arteries have the same point of origin (L₁) and are within the normal limits of origin; they have the same caliber (5 mm), also within normal values. The difference between them is their length: the right artery measures 10 cm in length, while the left one only 4 cm, this because of the ectopic position and rotation of the right kidney. Another two pairs of accessory arteries (middle and inferior) are added. The right middle artery has the same level of origin as the left inferior one (L₃) and they have about the same length (4.3/4.2 cm). The right inferior artery originates in L₄, while the left middle artery originates in L₂, but they are both 6.2 cm long. The four accessory arteries have the same caliber and sinuous tract. Regarding the way of entering the kidney, the main arteries and the supernumerary middle ones penetrate the parenchyma through the hilum. The second pair of supernumerary arteries (the inferior renal ones) enters the inferior pole of the parenchyma, having the aspect of inferior polar arteries.

□ Conclusions

The ectopic kidney has clinical significance owing to its atypical location, malrotation and vascular particularities. Urine flow or renal vascular complications may occur in cases of ectopic kidney. In addition, the ectopic kidney is vulnerable to traumas because of its position. In the absence of clinical manifestations, it can be detected accidentally. CT angiography is a very accurate and minimally invasive method that allows the evaluation of the kidney position, its anatomical ratios, its vascularization and the morphometrical evaluation of various indices. This information proves very useful in urology cases requiring surgery or renal transplant.

References

- [1] ROMANES GJ, *Cunningham's Manual of Practical Anatomy. Vol. II: Thorax and Abdomen*, 15th edition, English Language Book Society, Oxford University Press, 1986.
- [2] LANG J, SCHMIDT R, *Über die Lagebeziehungen der Niere zu Nachbarstrukturen*, Morphol Med, 1982, 2(3):167–177.
- [3] INGOLE IV, GHOSH SK, *Laterally rotated kidney – a rare congenital anomaly*, J Anat Soc India, 2005, 54(1):19–21.
- [4] DAS S, AMAR AD, *Ureteropelvic junction obstruction with associated renal anomalies*, J Urol, 1984, 131(5):872–874.
- [5] PATTEN BM, *Human Embryology*, McGraw–Hill Book Co., New York–Toronto–London, 1953.
- [6] GUIDONI P, *Embryologie*, Editions Doin Deren et C^e Paris, 1968.
- [7] MOORE KL, *The developing human: clinically oriented embryology*, W.B. Saunders Co., Philadelphia, 1982.
- [8] GÜLSÜN M, BALKANCI F, ÇEKİRGE S, DEGER A, *Pelvic kidney with an unusual blood supply: angiographic findings*, Surg Radiol Anat, 2000, 22(1):59–61.
- [9] GÖDDE S, *Die Beckenniere*, Dtsch Med Wochenschr, 1968, 93(20):1013–1017.
- [10] HERTZ M, RUBINSTEIN ZJ, SHAHIN N, MELZER M, *Crossed renal ectopia: clinical and radiological findings in 22 cases*, Clin Radiol, 1977, 28(3):339–344.
- [11] CAMPBELL MF, HARRISON JH (eds), *Urology*, 2nd edition, W.B. Saunders Co., Philadelphia, 1970.
- [12] DRETLER SP, OLSSON C, PFISTER RC, *The anatomic, radiologic and clinical characteristics of the pelvic kidney: an analysis of 86 cases*, J Urol, 1971, 105(5):623–627.
- [13] ASGHAR M, WAZIR F, *Prevalence of renal ectopia by diagnostic imaging*, Gomal J Med Sci, 2008, 6(2):72–76.
- [14] MOORE KL, PERSAUD TVN, *The developing human: clinically oriented embryology*, 8th edition, Elsevier–WB Saunders, Philadelphia, 2008, 244–256.

Corresponding author

Delia Elena Zăhoi, Professor, MD, PhD, Department of Anatomy and Embryology, "Victor Babeș" University of Medicine and Pharmacy, 2 Eftimie Murgu Square, 300041 Timișoara, Romania; Phone +40722–288 587, e-mail: dzahoi@umft.ro

Received: March 10th, 2010

Accepted: June 30th, 2010