

Original Anatomical Case Report

Right Ectopic Pelvic Kidney and Bilateral Vascular Aberrations a Female Donor: A Case Report

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Abstract: During an abdominopelvic cavity dissection in an undergraduate gross anatomy course, a right ectopic pelvic kidney was identified in the lesser pelvis and was concomitant with bilateral vascular aberrations. The right kidney was located anterior to the sacrum and medial to the right common iliac artery bifurcation with aberrant vasculature. The left kidney was located near the traditional T12-L3 level; however, multiple aberrant arteries supplied this kidney as well. Such renal anatomy anomalies have immediate implications in anatomy and embryology education, medical imaging, abdominopelvic surgical approaches, and the field of nephrology regarding renal form, function, and pathophysiology.

Keywords: pelvic kidney, ectopic kidney, renal aberrancies, renal artery, renal vein.

Introduction

The adult kidneys are retroperitoneal organs encapsulated in perirenal fat adjacent to the posterior abdominal wall. The adult kidneys are located at the level of the T12 – L3 vertebrae, with the left kidney typically located roughly one vertebral level superior (El-Galley et al. 2000). The renal arteries originate from the abdominal aorta approximately 14.5 mm (right) to 18 mm (left) inferior to the superior mesenteric artery and are anatomically referenced at the L1 – L2 vertebral level (Beregi et al. 1999; Kim et al. 2022). Anatomical variations of the kidney

and accompanying vasculature have been reported in both cadaveric studies and preoperative imaging. For example, an atypical (ectopic) position of the kidney may occur in an estimated 1 in 2000 - 3000 cases (Satyapal et al. 2001; Alvarez et al. 2021); however, vascular aberrations have been reported in up to 30% of the population (Gencheva et al. 2019). This case describes the observation of an ectopic pelvic kidney with renal vascular aberrancies in an undergraduate gross anatomy course. The anatomical irregularities observed during this dissection encouraged educational discussions including the implications of embryological

development, pre-surgical screening, and chronic and acute renal disease.

Case Presentation

This case presentation is from an 80-year-old female donor with a history of heart disease and dementia, who donated her body through the West Virginia Human Gift Registry. During routine dissection, the gastrointestinal tract was removed to expose the retroperitoneal cavity and the posterior abdominal viscera. During the inspection of the retroperitoneal cavity, the left kidney and suprarenal gland were observed; however, the right side was void of the viscera and all corresponding structures. The abdominal aorta and inferior vena cava were inspected, during which the absence of the typical paired renal vasculature was confirmed.

The renal fascia of the left kidney was palpated, bisected, and then the kidney was separated from the surrounding perirenal fat (Figure 1). The left kidney was located slightly lower than the T12-L3 vertebral level with an external renal pelvis (RP) and the corresponding ureter (UR) positioned along the ventral surface of the kidney. The left renal vein (LRV) traversed anterior to the abdominal aorta from the kidney to the inferior vena cava (IVC). The renal artery typically lies posterior to the renal vein; however, there was no renal artery posterior to the left renal vein in the donor. Subsequent dissection revealed two aberrant renal arteries supplying the left kidney. The first variation (LARA1) branched from the common iliac artery, just inferior to the aortic bifurcation, and supplied the kidney inferior to the left renal vein. A second aberrant left renal artery (LARA2) branched from the proximal aspect of the internal iliac artery and supplied the inferior pole of the left kidney. Figure 2

displays a zoomed-in view of the arterial variations of the left kidney.

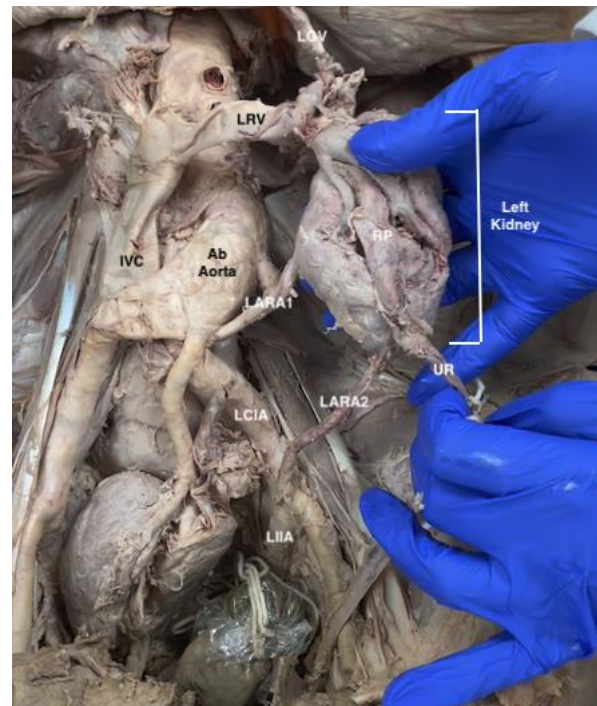


Figure 1. Left kidney and aberrant vasculature, with traction on the left ureter. Key: UR, Ureter; IVC, inferior vena cava; LK, left kidney; LRV, left renal vein; LGV, left gonadal vein (reflected superiorly); LARA1, first left aberrant renal artery; RP, renal pelvis; LCIA, left common iliac artery; LARA2, second left aberrant renal artery; LIIA, left internal iliac artery.



Figure 2. Left renal vascular aberrations (zoomed-in view).

Key: **LARA1**, first left aberrant renal artery; **LCIA**, left common iliac artery; **LARA2**, second left aberrant renal artery; **LIIA**, left internal iliac artery.

During subsequent dissection of the lesser pelvis, a fatty mass was located inferior to the aortic bifurcation on the right side with a single aberrant artery supplying the encased tissue. Removal of the fatty tissue revealed a small ectopic pelvic kidney. The superior pole was anterior to the sacral promontory, and the inferior pole was medial to the right internal iliac artery (Figure 3). Examination of the right ectopic pelvic kidney revealed a single right aberrant renal artery (RARA) branching from the distal portion of the abdominal aorta near its bifurcation and a right aberrant renal vein (RARV1) which ran from the kidney, posterior to the abdominal aorta to drain into the inferior vena cava, posterior to the dashed circle (Figure 3). The right kidney was reflected medially to reveal a second aberrant renal vein (RARV2) and a right ureter exiting the inferior pole. The RARV2 was attached to the right internal iliac vein (RIIV) (Figure 4).

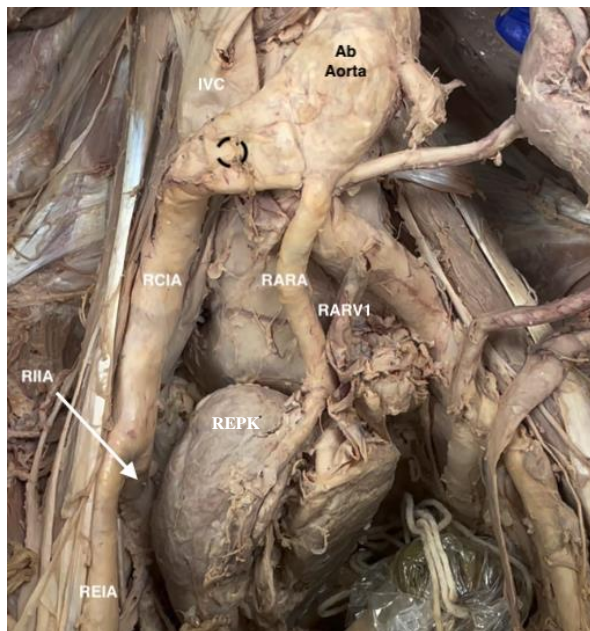


Figure 3. Right ectopic pelvic kidney. Key: **REPK**, right ectopic pelvic kidney **IVC**, inferior vena cava; **RCIA**, right common iliac artery; **RARA**, right aberrant renal artery; **RARV1**, superior right aberrant renal vein, **RIIA**, right internal iliac artery;

REIA, right external iliac artery. **RARV1** is detached, with attachment on the IVC posterior to the dashed circle.

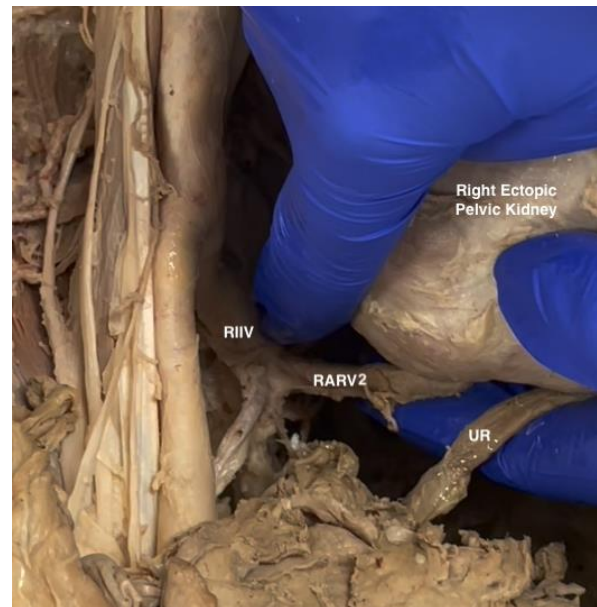


Figure 4. Right ectopic pelvic kidney. Key: **RIIV**, right internal iliac vein; **RARV2**, inferior superior right aberrant renal vein, **UR**, ureter.

Discussion

We present a case observed during the dissection of the retroperitoneal cavity during an undergraduate gross anatomy class. The dissection revealed a left kidney located at the expected position, near the T12 – L3 level. Removal of the perirenal fascia and perirenal fat exposed the left kidney with a ventrally facing external renal pelvis, two small aberrant renal arteries, and a single renal vein exiting the kidney to the inferior vena cava. The arterial supply consisted of a small aberrant renal artery that entered the kidney via the renal hilum from the left common iliac artery and an inferior aberrant renal artery entering the inferior renal pole from the left internal iliac artery. The normally positioned single renal vein exited the kidney at the renal hilum, traversed the anterior abdominal aorta, and attached to the inferior vena cava.

The right kidney was observed in the lesser

pelvis positioned medially to the right internal iliac artery and was considered an ectopic pelvic kidney. This kidney presented with a ventrally facing renal pelvis, a single aberrant renal artery, and two aberrant renal veins. Blood flow to the kidney was supplied via a small single renal artery entering the renal hilum from the distal aorta. Rather than a single renal vein, the right kidney exhibited a tenuous superior renal vein that exited the kidney at the renal hilum and flowed superiorly into the inferior vena cava and a second renal vein exited the renal pelvis and ran inferiorly into the right internal iliac vein.

The classical anatomical description of the kidneys and corresponding vasculature consists of a paired artery and vein for each kidney (Bouali 2012); however, the vascular supply of the kidney may be highly variable (Eid et al. 2018). Bouali et al. and Gencheva et al. (2019) report that variations in the renal vessels may occur in up to 30% of the population. Our unique case describes bilateral vascular variations that originate away from the abdominal aorta's normal L1 – L2 vertebral level for arterial supply to the kidney and venous return at the corresponding level to the inferior vena cava. Bouali et al. indicate that the bilateral variations seen in this case study are uncommon and only present in roughly 10% of the population that presents with vascular variations.

This case also reports an ipsilateral (right) ectopic pelvic kidney positioned in the lesser pelvis medial to the psoas major and right internal iliac artery. Renal ectopia refers to a kidney situated in an abnormal position whereas the pelvic kidney describes the ectopic location below the aortic bifurcation in the presacral area (Chyu 2021). The ectopic

pelvic kidney is a congenital anomaly that occurs in approximately ~1 in 2000 - 3000 cases (Gencheva et al. 2019) and a majority of those cases (75%) occur unilaterally. (Bernard et al. 2021). Pelvic kidneys are often asymptomatic and are often found during dissection or imaging (Bernard, et al.; Gencheva, et al.; Yushkov et al. 2009). However, the ectopic pelvic kidney has been characterized as having morphological and vascular irregularities, such as 1) vascular variations, 2) reduced size, 3) incomplete medial rotation of the renal pelvis, and (4) abnormal (short) ureters (Yushkov et al.). In our case, the right ectopic pelvic kidney presented with the abnormalities cited. The kidney in this case resided below the aortic bifurcation and presented with arterial and venous variations, a smaller morphology than a normal kidney, a ventrally facing renal pelvis that did not rotate medially along the longitudinal axis, and a short ureter.

The ectopic pelvic kidney and the renal vasculature occurred as a congenital anomaly that developed during the early stages of urogenital formation. As the kidneys ascend, they receive vascular supply through transient arteries originating at successively higher levels on the aorta (Fukuoka et al. 2019; Gulas et al. 2018; Mazengenya 2016). These arteries usually degenerate, giving way to the final and persistent renal artery exiting the aorta at the L1-L2 vertebral level (Kim et al. 2022; Beregi et al. 1999). Congenital anomalies in the renal arteries have been reported to occur in up to 30% of the population (Kim et al. 2022; Satyapal et al. 2001) and may include the persistence of one or more of these transient arteries.

Embryological development of the renal

system is highly complex and involves multiple stages susceptible to variation in adult anatomy. The permanent kidneys develop from the metanephros system during week 5 of gestation (Eid et al. 2018; Fukuoka et al. 2019; McCance and Huether 2019; Mompeó et al. 2019). Originating in the sacral region, S1-S2, these kidneys undergo the process of ascension and medial rotation until halted by the suprarenal glands at the T12-L3 level. Regulation of the ascension and rotation process remains unclear, though likely theories point to the diminution of body curvature (straightening) and differential growth of the lumbar and sacral regions. During the ascent, the kidneys must pass through a tight space formed by the arterial fork of the umbilical arteries. As such, congenital aberrancies such as ectopic kidneys may develop. An ectopic kidney occurs when one or both kidneys fail to pass through this fork and may halt ascension to the T12-L3 vertebral level. An ectopic kidney failing to ascend out of the presacral area is termed a pelvic kidney. During ascension, the kidney hilum is situated ventrally, and the kidney rotates medially ninety degrees until the hilum faces the midline in its final position (Fukuoka 2019). Kidneys halted during ascension may fail to undergo medial rotation and present with the hilum located ventrally. Ectopic kidneys present most commonly as an incidental radiological or surgical finding. However, the abnormal development and final location of an ectopic kidney poses clinical significance for several associated pathologies. Atypical blood supply often following an abnormal course may contribute to hypertension secondary to inappropriately increased renin (Gencheva, et al., Gulas, et al. 2018). Malrotation may be associated with vesicoureteral reflux and increased risk of

urinary tract infections, and the vulnerable location of the pelvic kidney poses higher risk for trauma-induced injury (Gencheva et al.). Consideration of the ectopic kidney is warranted in the clinical presentation of such conditions as well as approaches to abdominopelvic surgery.

Educational Significance

This case represents an anatomical anomaly causing a divergence from the conventional dissection. As such, the teaching of a standard gross anatomy course may expand to include the study of integrative biology and clinical application. From this dissection, the following pedagogical outcomes have been developed for this case study and other anatomical variations with clinical implications:

- **Clinical Case Studies** (Grand Rounds): Students will research and deliver anatomical or clinical case presentations on potential variations or congenital defects before class. This case demonstrates a remarkable variation from the classical description of anatomy. Case studies will help the students critically analyze the pending dissection and develop a more comprehensive understanding of embryology, the interplay between different systems, and insight into the clinical significance of anatomical variations.
- **MRI, CT, radiology, or other imaging research:** The students will research online journals for images for teaching anatomy or pre-surgery screening. Doomernick et al. (2017) indicated that anatomical knowledge

retention was higher when clinical cases, images, and practical aspects of anatomy were used in problem-based learning. As such, using images or clinical scenarios to understand form and function, the impact of disease, or for pre-screening can help make the connection between anatomy and practical use.

- **Pathophysiology:** The students will research different conditions associated with anatomical variations (e.g., in this kidney example, the potential reduction of blood flow to the kidney and hypertension). Gulas et al. (2015) and Gencheva et al. (2019) indicate that the short, slender, and tortuous renal arteries can lead to decreased renal perfusion, increased plasma renin levels, and increased persistent hypertension. The cause of death for our donor was listed as cardiovascular disease and although the pathology of her disease cannot be determined, the correlation between renal function and cardiovascular disease can be introduced.

Summary

The ectopic pelvic kidney is a congenital condition characterized by the final kidney residing below the aortic bifurcation. This case reports a unilateral right pelvic kidney and bilateral atypical vascularization. This case represents a unique example of how anatomical variations can help anatomists integrate the branches of anatomy and physiology as well as introduce students to potential clinical implications of clinical anatomy using imaging or problem-based learning.

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