Horseshoe kidney with extrarenal calyces and malformed renal vessels

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SUMMARY

The horseshoe kidney is a congenital fusion anomaly where both kidneys are fused at the lower poles. We report a case of horseshoe kidney in a 70 year-old Thai cadaver. This horseshoe kidney was associated with malformations of renal hila, sinuses, calyces and supernumerary arterial supplies from the dorsal part of the kidney. To our knowledge, the arterial supply to the horseshoe kidney from the dorsal aspect has never been reported.

Dissection revealed six aberrant renal arteries directly originated from the abdominal aorta supplying directly the renal segments. We believe that it was probably due to the persistence of mesonephric arteries. Also, the ascension of the horseshoe kidney in the present case was restricted by one of the renal arteries, not the inferior mesenteric artery. The embryology, anatomy, and the clinical significance of the present case are discussed.

Key words: Horseshoe kidney – Extrarenal calyx – Extrarenal pelvis – Dorsal renal artery – Anatomical variation

INTRODUCTION

Horseshoe kidney is the most common type of congenital renal fusion anomaly, which is characterized by three developmental anomalies: ectopia, malrotation and vascular changes. The occurrence of the horseshoe kidney is approximately 0.25 percent of the general population (Allen, 1951) and is twice more prevalent in men than in women (Basar et al., 1999).

Individuals with horseshoe kidney are more vulnerable to obstruction of the urinary flow at the pelviureteric junction, infection and renal stone formation (Fowler, 1995). Horseshoe kidney is also known to coexist with abnormal formations of renal vessels, which may duplicate or triplicate, and may also vary between sides. To our understanding, no previous study has reported the presence of the horseshoe kidney with blood supply from the dorsal aspect. Herein we present a case of a horseshoe kidney in a 70 year-old male Thai cadaver with dorsal blood supply and extrarenal calyceal system. The embryonic development, classification and clinical significance of the present case are discussed.

CASE REPORT

During a routine dissection of an undergraduate anatomy course, a horseshoe kidney was discovered in a 70 year-old male Thai cadaver (Fig. 1), who died from myocardial infarction. This horseshoe kidney was seen towards the left side of the median line with the left lobe lying more superiorly than the right lobe. The dimension of this horseshoe kidney was 14.8 centimetres in length (measuring from the left and right borders) and 13.0 centimetres in width (measuring from the superior to the inferior border). It was situated at L3-4 lumbar vertebral level. The anomaly appeared to be associated with malformations of renal hilum, calyces, pelvis and the abnormal renal vessels. The definitive renal hilum was absent, and the renal sinuses could not be identified. The supernumerary renal vessels entered and exited the kidney independently. The calyceal system of both sides was extrarenal, which appeared on the anterior part of horseshoe kidney

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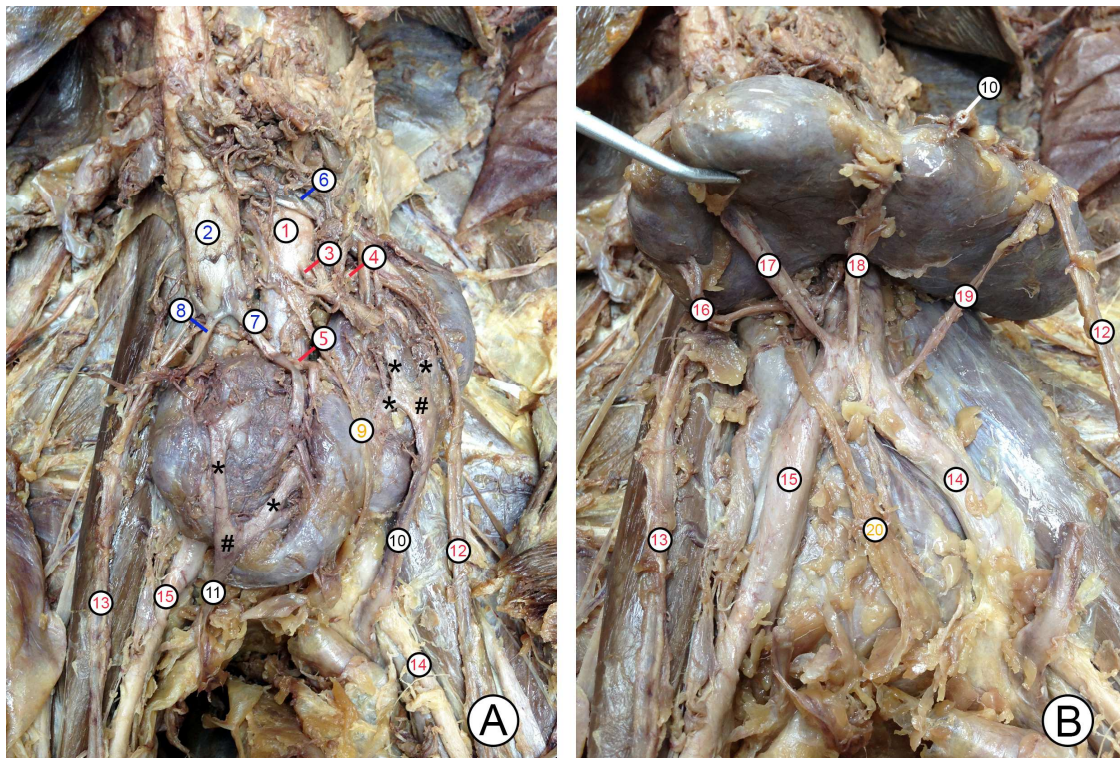
Fig. 1. The horseshoe kidney in a 70-year-old Thai cadaver on the anterior aspect **(A)** and 5 on the posterior aspect **(B)** of the kidney showing the abdominal aorta (1), inferior vena cava (2), inferior mesenteric artery (3), first and second renal arteries (4-5), left renal vein (6), first right renal vein (7), second right renal vein (8), anterior aortic plexus (9), left ureter (10), right ureter (11), left testicular vessels (12), right testicular vessels (13), left common iliac artery (14), right common iliac artery (15), third, fourth, fifth, and sixth renal arteries (16-19), and superior hypogastric plexus (20), renal calyces (asterisks), and renal pelves (number signs).

(Fig. 1). There were 2 and 3 major extrarenal calyces for the left and the right lobes, respectively. Some minor calyces were also observed outside the renal mass. The location of the ureteropelvic junction of the left and the right side appeared at the inferior rim on the anterior part of the kidney (Fig. 1). The left ureter descended on the anterior side of the left common iliac artery, whereas on the right side it descended medial to the right common iliac artery.

Blood vessels of the present case did not follow the definitive renal vessels. It received six sources of arterial supply, two superior to the kidney, and the other four from the dorsal aspect of the kidney (Figs. 1, 2A). The first and second branches took origin from the abdominal aorta superior to the kidney and inferior to the inferior mesenteric artery. The first branch supplied the superior segment of the left kidney. The second branch divided into two, one supplying the anterior segment of the left lobe, and the other supplying the anterior segment of the right lobe. The third, fourth, fifth and sixth branches were seen on the dorsal aspect of the kidney. The third branch was from the abdominal aorta supplying the superior segment of the right lobe. The fourth branch originated from the right common iliac artery supplying the posterior segment of the right lobe. The fifth branch originated from the abdominal aorta at the level of the aortic

bifurcation supplying the isthmus. The sixth and the most distal branch was a branch from the left common iliac artery supplying the posterior segment of the left lobe. All renal arteries arrived directly to the renal parenchyma. The left and the right testicular arteries both took their usual origin from the abdominal aorta (Fig. 2A).

The venous drainage of each side was different. On the left side, it was drained by a single large vein which was similar to the definitive left renal artery, whereas on the right side it was drained by two smaller veins: the first and second renal veins (Figs. 1A, 2B). The left renal vein received venous drainage from the left inferior suprarenal vein. There was a communicating vein connecting the two right renal veins (Fig. 2A). The left testicular vein drained directly to the left renal vein, whereas the right testicular vein joined the inferior vena cava at around the same level of the right renal veins. The aortic plexus appeared anterior to the aberrant kidney, whose fibres inferiorly connected the superior hypogastric plexus (Fig. 1B). No other malformations of gastrointestinal structures and the skeletal system were observed. The isthmus was located 4.9 centimetres below the inferior border of the inferior mesenteric artery. The isthmus appeared adjacent to, and had a close relationship with, the second renal artery.
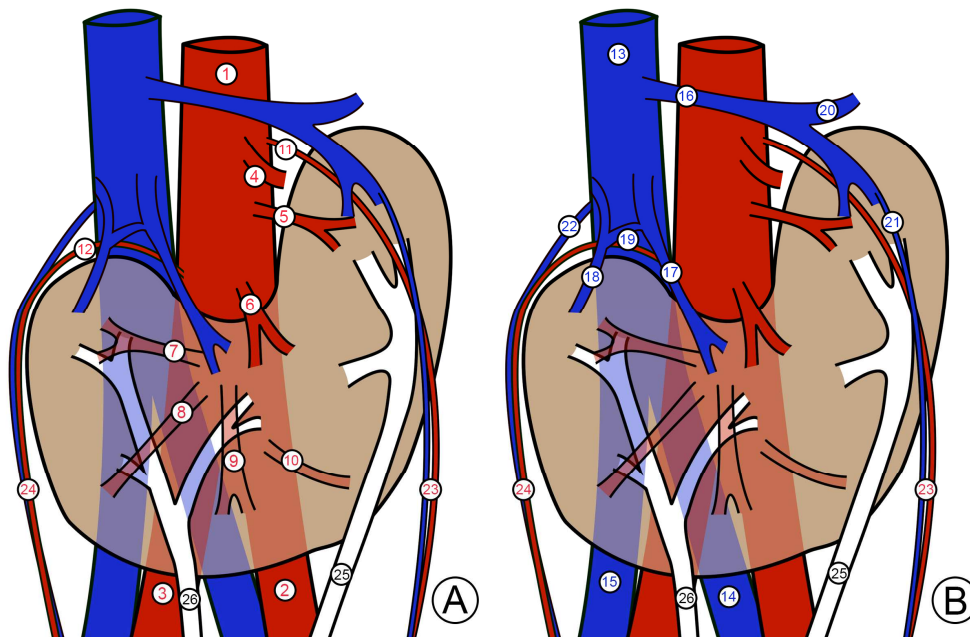
Fig. 2. Schematic drawing of the horseshoe kidney in the present case showing the arterial supply **(A)** and the venous drainage **(B)**. Abdominal aorta (1), left common iliac artery (2), right common iliac artery (3), inferior mesenteric artery (4), first, second, third, fourth, fifth and sixth renal arteries (5-10), left testicular artery (11), right testicular artery (12), inferior vena cava (13), left common iliac vein (14), right common iliac vein (15), left renal vein (16), first right renal vein (17), second right renal vein (18), communicating branch of right renal veins (19), left inferior suprarenal vein (20), left testicular vein (21), right testicular vein (22), left testicular vessels (23), right testicular vessels (24), left ureter (25), and right ureter (26).

DISCUSSION

The horseshoe kidney in the present case had the following characteristics: (i) a lower position in the abdomen; (ii) extrarenal calyces with the hilum facing the ventral side; and (iii) supernumerary and aberrant renal arteries on the ventral and dorsal sides. Normal embryogenesis of the kidney proceeds through a series of successive stages: the pronephros, mesonephros, and metanephros. During the fifth week of gestation, the mesonephros starts to degenerate while the metanephric mass or the permanent kidney begins to develop on each side of the embryo. Moreover, a ureteric bud originates from the caudal end of the mesonephric (Wolffian) duct, expands and subsequently divides to form the renal pelvis, renal calyces and the collecting duct system of the kidney. Rarely, the two metanephric masses may fuse and form the isthmus, which attributes to a condition called the horseshoe kidney. As the development progresses in the elongating fetus, the kidney ascends from the pelvic to its mature location in the retroperitoneum. It takes new arterial supply from the aorta as the kidney migrates cranially. This ascension is then accompanied by medial rotation, resulting in the renal hilum to appear on the medial side. In contrast to the ascension of the normal kidney, when the horseshoe kidney ascends, the isthmus is obstructed by the inferior mesenteric artery causing it to be trapped in the lower abdomen (Basso et al., 2011). Also, the fusion prevents the kidney from medial rotation causing the renal calyces and the ureter to appear anteriorly (Sadler, 2011). This is probably the explanation for the extrarenal calyceal system and the absence of the definitive renal hila in our case.

It is commonly known that the blood supply of the horseshoe kidney is greatly variable. Blood supply to the horseshoe kidney can originate from the abdominal aorta, common iliac artery, and inferior mesenteric artery (Basso et al., 2011). It may be atypical, duplicated or triplicated, which can also vary between two sides (Glenn, 1959). In the present case, there were six renal arteries, four taking origin from the abdominal aorta and the other two from the left and right common iliac arteries supplying individually each renal segment. Out of the six renal arteries, four renal arteries originated from the dorsal part of the kidney. Natsis (2014) reported that dorsal blood supply to the horseshoe kidney has never been reported. Graves (1969) in his report classified the horseshoe kidney into six types according to patterns of arterial supply to each renal segment. Based on Grave's classification, the horseshoe kidney in the present case does not fall into any of the cate-

gories, but appeared to be a combination of Type 1e and Type 1f. Natsis et al. (2014) in their review found that the horseshoe kidney with multiple renal arteries (greater than or equal to three) existed in 45 out of 71 cases. These arterial variations reflect the continuous changes of the developing embryonic kidneys. These variations are the result of premature ablation of the segmental arteries off the aorta as the kidney migrates from pelvic to lumbar position (Gray and Skandalakis, 1972). Several authors (Vaniya, 2004; Kocabiyik et al., 2004; Künzel et al., 1988) believed further that these malformed renal or segmental arteries were specifically the persistent mesonephric arteries. The mesonephric arteries develop on each side of the aorta, and are distributed along the mesonephric area from the sixth cervical to the third lumbar segments. The mesonephric arteries originally supply the mesonephros, but later they supply the suprarenal glands, the reproductive glands and the metanephric mass or the kidney (Kocabiyik et al., 2004). As the mesonephros starts to degenerate, the more cranial mesonephric vessels begin to disappear. Caudally, there might be a persistence of some mesonephric arteries as the caudal ones are the last to degenerate. Such persistence may give rise to the accessory renal or segmental arteries originating from the aorta (Boatman et al., 1971; Vaniya, 2004). Generally, the inferior mesenteric artery is upon the isthmus preventing the ascent of most cases of the horseshoe kidney (Basso et al., 2011). However, the ascent of the horseshoe kidney in the present case was arrested by one of its own renal arteries rather than the inferior mesenteric artery, which was located 4.9 centimetres above the isthmus. This confirms that the horseshoe kidney in the present case had no relationship with the inferior mesenteric artery. A similar case was also reported by Yoshinaga (2002).

The understanding of the anatomy of the horseshoe kidney lies in the context of clinical implications. It is known to be associated with various congenital abnormalities. Glenn (1959) reported that the incidence of associated congenital anomalies in fetuses and infants, children, and adults were 78.9%, 28.5%, and 3.5%, respectively. These findings suggested that individuals with the horseshoe kidney might be more vulnerable and incapable of long-term survival. A portion of individuals with chromosomal abnormalities such as Patau, Gardner, Down and Turner syndromes have been reported to coexist with the horseshoe kidney (Natsis et al., 2014). Patients with the horseshoe kidney do not have protection from the lower ribs, and are therefore more prone to compression and laceration against the vertebral column caused by abdominal trauma (Lee et al., 2007). Awareness of the presence of the horseshoe kidney is clinically signifi-

cant, especially during surgery in the lower abdomen. Division of the isthmus may be required to fully expose the abdominal aorta during surgery of abdominal aortic aneurysm associated with the horseshoe kidney (Saadi et al., 2008). To preserve renal function, renal arteries should be reimplanted as quickly as possible after the aortic reconstruction (Townsend, 2002). Over 100 horseshoe kidneys have been transplanted in the last three decades (Basso et al., 2011). Understanding of the variations of renal vessels and careful considerations of the donor and recipient are key to successful transplants (Basso et al., 2011).

In conclusion, this study reports a case of the horseshoe kidney associated with extrarenal calyces and malformations of renal vessels. The anatomy, embryology and clinical significance are stressed. We wish that the present study may provide anatomical and surgical knowledge of the horseshoe kidney, and also generate more interest in anatomical variations.

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