Anatomical Investigation Following Incidental Horseshoe Kidney Finding

Alexandra Cain, Brannan De Voto Noonan, Sara Eliseo, Anthony Sciuva, Leslie Pryor McIntosh PhD
Department of Biomedical Sciences, Philadelphia College of Osteopathic Medicine, Moultrie, GA

ABSTRACT

Horseshoe kidneys are congenital anomalies that result from the fusion of the right and left kidneys across the midline of the abdomen after both kidneys failed to ascend during fetal development. During a standard educational dissection of 12 donor bodies from the Body Donor Program at PCOM Georgia, a horseshoe kidney was discovered in an 88-year-old female with a reported fatality related to left lung carcinoma, encephalopathy, and hypercalcemia. The circumstances of this discovery presents an opportunity to explore the anatomical arrangement of the congenital malformation in detail. Anatomical dissection and analysis of the neurovascular and renal organization was documented with marked differences from traditional structural arrangement. A parenchymatous isthmus was formed superficial to the abdominal aorta by the fusion of the lower poles of the right and left kidneys. Additionally, other anatomical abnormalities present were identified and recorded. This study could be utilized to inform providers of best practices regarding patients with horseshoe kidneys.

INTRODUCTION

A horseshoe kidney (HSK) is a common, often asymptomatic, congenital abnormality of unique appearance. The prevalence within the general population is about 0.25% and occurs twice as often in males compared to females [1,2]. A majority of congenital horseshoe kidney (HSK) patients are asymptomatic [8]. However, it has previously been associated with several genetic defects [3]. The deformity is defined by a fusion of both kidneys across the midline at the upper or lower poles. A “typical” case has three distinct changes of ectopia, malrotation, and vascular changes [4]. This case report is designed to inspect the anomaly in a cadaveric specimen and identify any significant differences in comparison to previously analyzed specimens.

METHODS

A standardized dissection protocol established by the program directors at PCOM was performed. During the dissection designated to examine the large abdominal vessels and the posterior abdominal wall, the HSK was identified promptly by its pronounced irregularity. The standard dissection protocol was discontinued within the pertinent anatomical region.

Preservation of all involved structures was prioritized to promote accurate visualization of the tissues in situ, with careful consideration given to the vasculature. Once optimal visualization was achieved, multiple photographs were taken of the HSK in situ for general reference and to highlight distinct features. At this point, the HSK was excised from the body with relevant accompanying vasculature for further examination. The internal structures of the horseshoe kidney were investigated and measured.

ACKNOWLEDGEMENTS

We would like to extend our thanks to the both the body donor and their family for the immense contribution to our education. We would also like to thank the lab director for his patience and knowledge throughout this process.

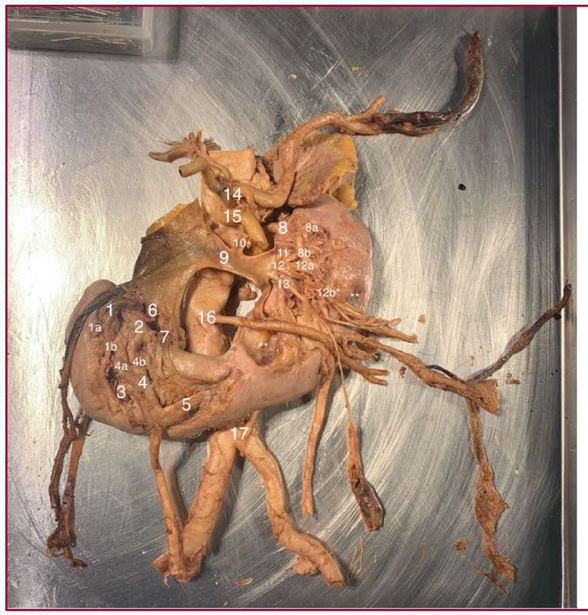
RESULTS

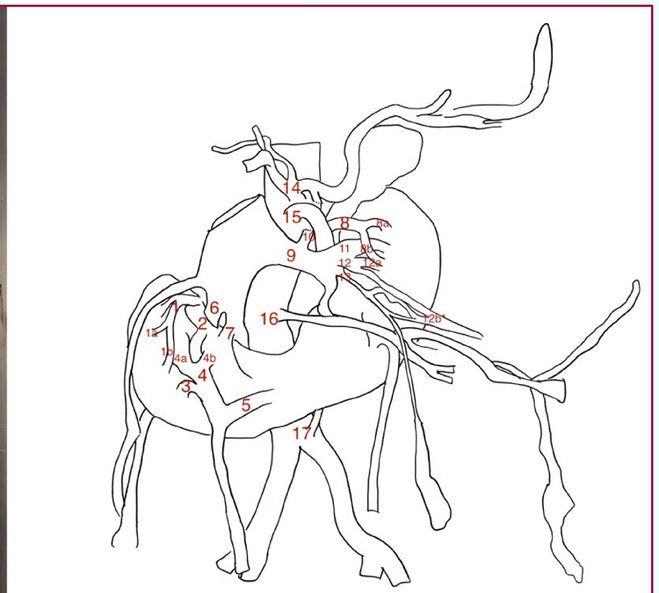
The HSK weighed a total of 162 grams and measured 148 mm in width from each of its widest points. The kidneys were fused at their lower poles, ventral to the abdominal aorta and between the vertebral levels of L3 and L4, forming an isthmus of parenchymal origin. The isthmus,measured 31 mm in length, was positioned obliquely to the left and sat between two arteries arising from the abdominal aorta. The superior border of the isthmus was located 27 mm away from the inferior mesenteric artery, and the inferior border was 18 mm away from an accessory renal artery. This renal artery supplied the isthmus and middle region of the horseshoe kidney.

The left kidney was more superior than the right kidney with its superior border at the vertebral level of T12. It weighed 72 grams and measured 105 mm in length. The kidney was well-developed with two cysts, one lateral to the isthmus measuring 26 mm by 22 mm and another on the lateral edge measuring 14 mm by 9 mm. The hilum was comprised of well-defined calyces and vasculature located on the superomedial surface. The less-developed right kidney weighed 86 grams, measured 92 mm in length, with the superior border above the vertebral level of L2, anterior to the inferior vena cava. The calyces and renal vessels were visible entering the hilum on the ventral surface.

Each kidney was supplied by a right and left renal artery, respectively, arising from the lateral abdominal aorta just below the superior mesenteric artery bilaterally. A single accessory renal artery, originating from the abdominal aorta, inserted in the left posterior aspect of the isthmus. It measured 44 mm in length from the aorta to its insertion point.

The right renal artery traveled posterior to the inferior vena cava, measured 52 mm in length, and terminated into anterior and posterior branches, with the superior segmental artery arising most superiorly off the posterior division. A right inferior suprarenal artery arose from the right renal artery, directly after branching off the abdominal aorta. The left renal artery measured 34 mm in length from its origin at the aorta to its bifurcation. There was no identifiable left inferior suprarenal artery branch point from the left renal artery. The left superior segmental artery branches off the posterior of the left renal artery. The anterior division of the renal artery on the ventral left kidney gave rise to three branches.





Right kidney:
1. Anterior division of the right renal artery
   a. Right anterior superior segmental artery
   b. Right anterior inferior segmental artery
2. Right inferior segmental artery
3. 1st major calyx of the right ureter
4. 2nd (middle) major calyx of the right ureter
   a. 1st minor calyx of the right ureter
   b. 2nd minor calyx of the right ureter
5. 3rd major calyx of the right ureter
6. Right superior renal vein
7. Right inferior renal vein

Left kidney:
8. Anterior division of the left renal artery
   a. Left anterior superior segmental artery
   b. Left anterior inferior segmental artery
9. Left renal vein
10. Left suprarenal vein
11. Left superior segmental vein
12. Left anterior segmental vein
    a. Left anterior superior segmental vein
    b. Left anterior inferior segmental vein
13. Left ovarian vein
    *anastomosis of left anterior inferior segmental vein
    **left kidney cysts

Other:
14. Celiac trunk
15. Superior mesenteric artery
16. Inferior mesenteric artery
17. Accessory renal artery

DISCUSSION

The fusion of the lower poles results in an asymmetrical “U" shaped kidney connected by the isthmus. The kidney formed in a left oblique position around the abdominal aorta, with the left kidney more superior than the right. The kidney location was largely consistent with other documented cases in regards to corresponding vertebral level [9] and structures of the abdominal aorta. Compared to the anatomic findings in other studies, an additional irregularity was noted as the inferior mesenteric artery deviated superiorly and to the left of the isthmus. There was the presence of an accessory renal artery branching off the left common iliac artery, immediately inferior to the bifurcation of the abdominal aorta, a common occurrence with HSK [9]. The renal arteries inserted into the immature hilum with exposed segmental branches. A cyst-like mass was observed on the anterior medial surface of the left kidney just posterior to the inferior mesenteric artery. A deviation from normal anatomy showed an anastomosis left ovarian vein with the left anterior inferior segmental vein.

Horseshoe kidneys may result from merging of the nephrogenic blastemas following a teratogenic event that produces an abnormal fusion involving parenchymal tissue at the isthmus [8]. This fusion inhibits normal ascent and lateral migration of the kidneys resulting in a deviation from normal maturation [9]. Several chromosomal abnormalities that are highly associated with the presence of a HSK. Trisomy 18 (Edward) and Trisomy 21(Down) have a high percentage of patients, 60% and 20% respectively, of developing a HSK [13]. It has also been correlated with Turner syndrome, the result of female infants with an absent or partially missing X chromosome [13].

CONCLUSION

This analysis demonstrated the individual specificity of the involved with the horseshoe kidney. There is an assortment of complications that occur at an increased proportion due to the malformed renal structures, including increased infection frequency [12], increased chance of kidney stones, and increased incidence of vesicoureteral reflux [8].

REFERENCES

1. Gupta, M., Pandey, A. K., & Goyal, N. (2007). Horseshoe kidney–a case report. Nepal Med Coll J, 9(1), 63-6.
2. Kang, M., Kim, Y. C., Lee, H., Kim, D. K., Oh, K. H., Joo, K. W., ... & Han, S. S. (2019). Renal outcomes in adult patients with horseshoe kidney. Nephrology Dialysis Transplantation.
3. Kirkpatrick, J. J., & Leslie, S. W. (2017). Horseshoe kidney.
4. Natsis, K., Piagkou, M., Skotsimara, A., Protogerou, V., Tsitouridis, I., & Skandalakis, P. (2014). Horseshoe kidney: a review of anatomy and pathology. Surgical and Radiologic Anatomy, 36(6), 517-526.
5. Stroosma, O. B., Scheltinga, M. R., Stubenitsky, B. M., & Kootstra, G. (2000). Horseshoe kidney transplantation: an overview. Clinical transplantation, 14(6), 515-519.
6. Taghavi, K., Kirkpatrick, J., & Mirjalili, S. A. (2016). The horseshoe kidney: surgical anatomy and embryology. Journal of pediatric urology, 12(5), 275-280.
7. Yohannes, P., & Smith, A. D. (2002). The endourological management of complications associated with horseshoe kidney. The Journal of urology, 168(1), 5-8.
8. O'Brien J, Buckley O, Doody O, et al. Imaging of horseshoe kidney and their complications. J Med Imag Radio Oncol. 2008;52:216-26.
9. Dimple M, Vaishaly B, Manvikar PR, et al. A study of horseshoe kidney: A rare anatomical variant. Int J Anat Var. 2017;10(4): 103-105.
10. Oktem, H., Gozil, R., Calguner, E., Bahcelioglu, M., Mutlu, S., Kurkcuoglu, A., ... & Kadıoglu, D. (2008). Morphometric study of a horseshoe kidney. Medical Principles and Practice, 17(1), 80-83.
11. Tijerina de la Garza, O., Uresti, J., Urrutia de la Vega, E., Elizondo-Omaña, R. E., & Guzman-Lopez, S. (2009). Anatomical study of the horseshoe kidney. Int. j. morphol, 491-494.
12. Bilge I, Kayserili H, Emre S, Nayir A, Sirin A, Tukel T, Bas F, Kilic G, Basaran S, Gunoz H, Apak M. Frequency of renal malformations in Turner syndrome: analysis of 82 Turkish children. Pediatr Nephrol. 2000 Oct;14(12):1111-4
13. Chang P, Tsau YK, Tsai WY, Tsai WS, Hou JW, Hsiao PH, Lee JS. Renal malformations in children with Turner's syndrome. J Formos Med Assoc. 2000 Oct;99(10):796-8. PMID: 11061079