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Original Research Article

Study of Variations in Renal Hilar Anatomy and Morphometric Dimensions of the Human Kidney

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Abstract

Background: Variations in renal hilar arrangement patterns and morphometric dimensions are clinically relevant in this age of advancing modern medicine and minimally invasive surgery. The purpose of the present study is to record variations in renal hilar arrangement patterns and assess renal dimensions of length, width and thickness respectively.

Methods: Hilar regions of fifty isolated embalmed kidneys were carefully dissected and variations observed were photographed and documented. Renal dimensions were measured with digital calipers and values obtained were tabulated and analysed. Normal anteroposterior hilar arrangement pattern was observed in 72% cases. Anterior and posterior divisions of renal artery were observed in 24% cases with anterior division being the most anteriorly placed structure in 14% cases. The renal pelvis was situated between the divisions of the renal artery in 8% cases. Prehilar segmental branches anterior to renal vein were observed in 4% cases. Other variations seen included extrahilar branches (4%), superior polar artery arising from anterior division of renal artery, prehilar tributaries of renal vein and an additional renal artery in 1 case each. The mean renal length was 9.35+/- 0.98 cm for right and 9.25 +/- 1.25 cm for left kidneys, mean renal width 4.93 +/- 0.65 cm for right and 4.95 +/- 0.5 cm for left kidneys and mean renal thickness 3.77 +/- 0.7 cm for right and 3.86 +/- 0.53 cm for left kidneys respectively. No statistically significant difference was observed in the mean values between right and left sides. The clinical implications of these findings have been discussed. The findings of this study may enhance the existing literature and contribute additional information for improving treatment outcomes during clinical and surgical interventions.

Keywords: Variation, Hilum, Kidneys, Morphometry, Arrangement Pattern, Dimensions.

Introduction

In this current era of rapidly advancing modern medicine, an in-depth anatomical understanding of the human body is an essential prerequisite for successfully performing medical, radiological and surgical procedures. The kidneys are paired retroperitoneal organs situated in the posterior abdominal wall, on either side of the vertebral column. In addition to excretion, they also play a role in red cell formation as well as calcium and mineral metabolism through the release of erythropoietin and renin respectively. IN each kidney, a deep vertical fissure in the medial border opens anteromedially as the hilum, which is bounded by anterior and posterior lips and contains the renal vessels and nerves, and the renal pelvis.[1]The relative positions of the main hilar structures are the renal vein (anterior), the renal artery (intermediate) and the pelvis of the kidney (posterior). [1]

Anatomical knowledge of the distribution of renal hilar structures is of crucial importance for urological surgical procedures in which hilar vessel clamping is necessary, either temporally or definitively, such as in conventional and laparoscopic nephrectomy, anatrophic nephrolithotomy and renal transplantation, as well as in interventions in which a pyelic incision is needed for the removal of calculi, such as conventional and laparoscopic pyelolithotomy. [2] With increasing incidence of small incidentally diagnosed renal tumours, laparoscopic partial nephrectomy (LPN) has emerged as an attractive minimally invasive treatment option [3] with shorter ischemia times, a lower complication rate, and equivalent long-term oncologic and renal functional outcomes, yet with decreased patient morbidity. [4] During LPN, clamping of individual structures at the hilum is preferred rather than en- bloc clamping. [5] Recent studies have demonstrated the need for careful hilar dissection with appropriate techniques of clamping renal vessels to prevent surgical complications and reduce post operative morbidity. [6,7] A precise knowledge of normal as well as variant anatomical arrangement patterns at the renal hilum is vital for the achievement of successful surgical outcomes with reduced complications and better patient recovery.

Morphometric changes in kidney dimensions may be associated with atherosclerotic renal disease, arterial hypertension, atherosclerotic renovascular disease or diabetes mellitus. [8] Furthermore, according to certain studies, it is possible to use renal size to predict the renal function in healthy individuals or patients with chronic kidney disease.[9]In this regard, the present study also attempts to determine anatomical dimensions of length, width and thickness of the kidneys which may provide added insight into currently available literature.

Materials and Methods

The present observational study was done in the Department of Anatomy at Nalanda Medical College, Patna, Bihar. Study duration of two Years. A total of 50 isolated (26 right and 24 left) embalmed cadaveric kidneys were obtained. Morphologically abnormal kidneys were excluded from this study. The prehilar and hilar regions of the kidneys were studied after careful dissection.

The anteroposterior arrangement of hilar structures was studied 0.5 cm from the anterior lip of the hilum. Variations encountered in hilar anatomy were photographed and documented. The kidneys were also morphometrically assessed for maximum length, width and thickness using digital calipers and values obtained were recorded. The renal dimensions were compared with respect to right and left kidneys by applying Independent t test with p value set at <0.05 in SPSS software version 21 for statistical analysis.

Results

We observed the classically described hilar anteroposterior arrangement of renal vein, renal artery and pelvis in 72% (36/50) cases. Variant arrangement patterns of the hilar structures were recorded in 28% (14/50) cases. The various hilar arrangement patterns observed in the present study are depicted in table 1. The renal artery divided into anterior and posterior divisions in 24% cases, with the anterior division being the most anteriorly placed structure in 14%(7/50) cases [Fig.2]. In 8% (4 cases), the renal pelvis was found to lie between the divisions of the renal artery with the renal vein being the anterior most structure at the hilum[Fig 3].

In 1 case, prehilar division of the renal vein into 2 anterior and 2 posterior tributaries were observed [Fig 4]. In addition to the above mentioned arrangement patterns, we observed multiple prehilar segmental branches of renal artery running anterior to the renal vein with crowding of the renal hilum in 4% (2)cases[Fig 5].A total of 3 extrahilar branches [Fig 2 & 6], including an extrahilar superior polar branch of renal artery were observed in 4%(2) cases. The superior polar artery arise from the anterior division of renal artery[Fig 6].

The remaining extrahilar branches arise from the renal artery [Fig 2] as well as from its anterior division[Fig 6].A single additional renal artery was found in 1 case, arising from the abdominal aorta and supplying the right kidney just below the hilum.

The length of the right kidneys ranged from 7.5 to 12 cm and those of the left kidneys from 6.5 to 13 cm. The mean renal length measured 9.35+/- 0.98 cm for right and 9.25 +/- 1.25 cm for left kidneys. Similarly, the width of right kidneys varied from 4 to 6.8 cm, with mean renal width being 4.93 +/- 0.65 cm. The width of left kidneys ranged from 4.2 to 6.5 cm and the mean renal width was 4.95 +/- 0.5 cm. Mean renal thickness was 3.77 +/- 0.7 cm for right and 3.86 +/- 0.53 cm for left kidneys respectively. Renal Thickness varied from 2 to 5 cm for right and 3 to 5 cm for left kidneys respectively. No statistically significant difference was observed in the mean values between right and left sides.

Table 1: Showing arrangement patterns of structures in renal hilum with percentage incidence

Hilar arrangement Pattern	**Percentage Incidence*(n=50)***
Rv-ra-pl	72(36/50)
Ad-rv-pd-pl	14(7/50)
Rv-ad-pl-pd	8(4/50)
At-ad-pl-pd-pt	2(1/50)

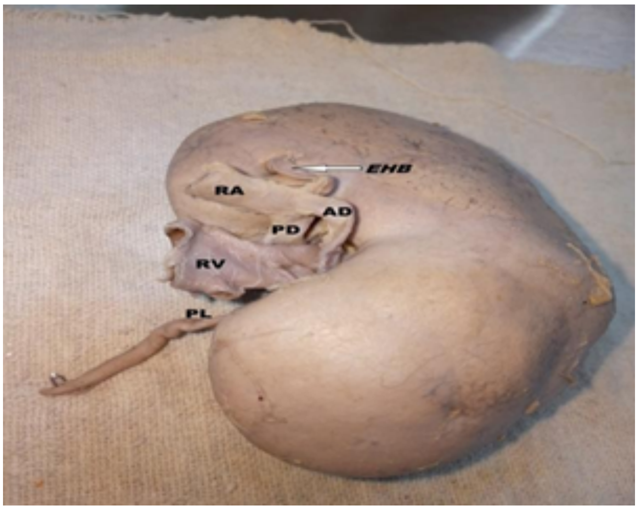

Figure 1: Showing AD-RV-PD-PL anteroposterior arrangement at renl hilum with extrahilar branch arising from

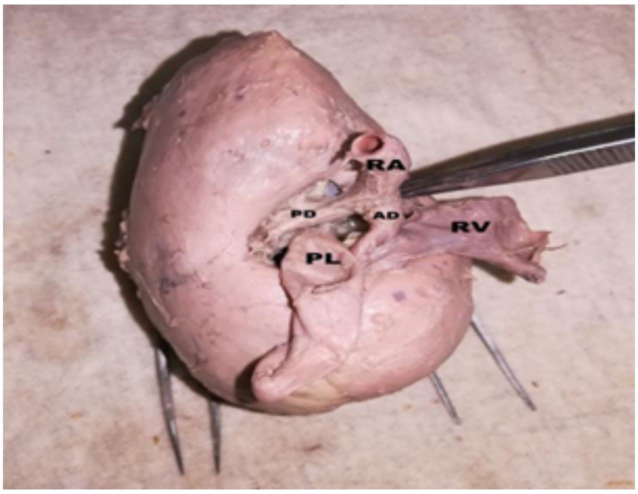

Figure 2: Showing RV-AD-PL-P Dantero posterior arrangement at renal hilum renal artery

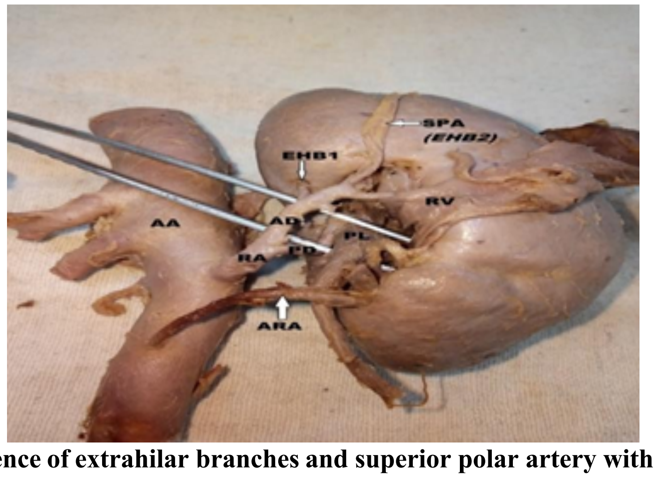

Figure 3: Showing presence of extrahilar branches and superior polar artery with additional renal artery

RV: Renal Vein; RA: Renal artery; AD: Anterior division of renal artery; PD: Posterior division of renal artery; PL: Renal pelvis; AA: Abdominal aorta; EHB: Extrahilar branches; SPA: Superior polar artery; ARA: Additional renal artery

Discussion

In this work, we have attempted to morphometrically assess renal dimensions and study different variations that may be encountered in the topographic arrangement of structures at the renal hilum, in consideration of its clinical and surgical importance. In our study, the conventional textbook described anteroposterior arrangement of renal vein-artery-pelvis at the hilum was observed in 72% cases. This is comparable with the findings of Joao[2] et al who observed this arrangement in 83% cases. In contrast, Trivedi et al[10] observed that hilar antero-posterior arrangement was not according to normal textbook description in majority (73%) cases, similar to Kumar et al[11] who also reports a relatively lesser incidence of normal arrangement pattern at 45.8% respectively. A comparison of our findings with those of previous studies has been summarised in table 2.

Table 2: Comparison of hilar arrangement patterns of present study with previous studies.

Hilar arrangement pattern	Trivedi et al [10]	Kumar et al [11]	Jadhav et al [12]	Divya et al [13]	Present study
RV-RA-PL	19%	45.8%	22.8%	32%	72%
AD-RV-PD-PL	23%	2.1%	5.26%	14%	14%
RV-AD-PL-PD	20%	8.3%	7.89%	12%	8%
AT-AD-PL-PD-PT	-	2.1%	-	-	2%

Prehilar segmental branches of the renal artery have been described by various authors [2,11,14,15] in the past and were observed in 4% cases of the present study. Segmental branches of the renal artery crowding the hilum may pose challenges during surgical hilar dissection as individual segmental arterial clamping though anatomically possible, is difficult to perform because of the high individual morphological variability. [14] Presence of multiple prehilar segmental branches increases risk of hemorrhage during renal transplantation, segmental ischemia and postoperative hypertension due to loss of parenchyma. [15] Trivedi [10] et al and Kumar [11] et al observed that variant arrangement of renal venous patterns at the hilum are more frequently left sided which might be due to the embryological formation of left renal vein from multiple anastomotic channels. This coincides with our study where we observed prehilar division of the renal vein into two anterior and two posterior tributaries in a left kidney.It has been suggested that anomalous arrangement of vessels in the renal hilum may occur due to rotational defects of the kidney [16] and may be associated with ureteropelvic obstruction. [17] Extrahilar superior polar branches of renal artery have been observed in 14.3% cases by Sampaio, [18] who used the term extrahilar to describe branches of renal artery with an extra-hilar penetration. In the present study, similar extrahilar branches were observed in 4% cases with an extrahilar superior polar artery arising from the anterior divison of the renal artery. The superior polar artery has been found to arise from main renal artery in 5.4% cases by Budhiraja [19] and in 17.2 % cases on the right side and 13.5 % cases on the left side by Saldarriaga [20]. Rao [21] et al in their study have considered extrahilar branching of renal arteries to be a normal pattern where the arteries divide to go to the respective segments. Similar observations have been made by Budhiraja[15]et al who observed prehilar multiple segmental branches in 11.66% cases. The branching pattern also depends on the form of the hilum with extrahilar branching often associated with a large hilum. [14]

Additional renal arteries have been assigned a wide range of nomenclature such as supernumerary ,aberrant, accessory, supplementary or multiple renal arteries by various authors.[22] As no definitive criteria has been established to name additional vessels entering the kidney and considering the varying schools of thought among different authors, we have used the term additional renal artery to describe our finding. Such additional renal arteries are common in 20-30% of individuals and may arise from the aorta, the main renal artery or other nearby arterial sources. [23,24] Available literature indicates that additional renal arteries are found in 9.76% of cadavers. [25,26,27] According to Graves, [28] accessory arteries are in fact normal segmental arteries whose origin is more proximal than usual. He explains that the aberrant renal artery is often the artery to the lower segment following an unusual course after taking origin from the aorta. Our finding of a single right sided accessory renal artery supplying the kidney just below the hilum falls in line with this description. Rizzari [29] states that individuals having kidneys with additional arteries have an increased incidence of hypertension. Accessory arteries supplying lower pole of kidneys may cause pelviureteric obstruction and hydronephrosis. [28] surgical complications and kidney loss. [27] The occurrence of accessory renal arteries may be explained by the persistence of embryonic vessels arising from the common iliac arteries or aorta, which are formed during the ascent of kidneys. [30]Accessory renal arteries may also be formed due to the failure of degeneration of caudal mesonephric arteries during kidney development. [26]

Conclusion

This study concludes that variations in hilar structural patterns and renal dimensions hold considerable clinical significance and need to be carefully identified for better treatment outcomes. The findings of this study may contribute to reinforce present literature and add to existing knowledge and research in this area.

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