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Original Research Article

Histo-pathological findings in kidneys with polar artery: a demystifying endeavor

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ABSTRACT

Background: The kidneys are supplied by renal arteries which enter the hilum and branch progressively from the pyramids to the cortex into lobar, interlobar, arcuate, interlobar, interlobular, and finally terminate as afferent arterioles that enter the glomeruli. Thus there is a normal pattern of blood flow towards the cortex from the pyramids when the artery enters at the hilum. The aim of the study was to explore the glomeruli pattern in kidneys with polar arteries.
Methods: The study was conducted in the department of anatomy at a tertiary care referral institute. Twenty-two kidneys with polar arteries were obtained by conventional method of dissection from cadavers for the study. Sections were taken from the upper pole and lower pole in each kidney. The sections were taken perpendicular and close to the polar arteries. The sections were subjected to routine histological processing and staining as per the standard operating procedure. Histological findings were observed and documented.
Results: The study found that the kidneys were histologically different with polar arteries as compared to normal kidneys. The number of glomeruli per high power field was higher nearer to the polar arteries. The glomeruli were viable and not sclerosed. An agglomeration of arterioles were present close to the polar arteries but they were distinct and did not seem to be associated with glomeruli.
Conclusions: The study found an agglomeration of arterioles, increased number of viable glomeruli and cystic changes associated with kidneys having polar artery. Thus this warrants a detailed study with special stains for research to elucidate the mechanisms of the circulation in polar arteries and correlation of the same findings with clinical conditions such as hypertension or any other diseases of the kidney.

Keywords: Arteries, Kidneys, Glomeruli

INTRODUCTION

The kidney has a segmental distribution of vascular segments. They are named apical, superior, middle, lower and posterior. These segmental arteries arise from the anterior and posterior divisions of the main renal artery. In a renal arteriogram the branches of the renal arteries can be seen dividing into five branches, each supplying a segment of the kidney. Each segmental artery provides a lobar artery to each pyramid. The lobar artery divides into two or three interlobar arteries that travel between pyramids. At the junction of the cortex and medulla they divide into two arcuate arteries and arch over the bases of the pyramids. These arcuate arteries give rise to interlobular arteries which course through the cortex perpendicular to the capsule. Interlobular arteries form the

boundaries of the renal lobule. The interlobular arteries give rise to afferent arterioles which supply blood to the glomerular capillaries. Blood passes from these capillaries into efferent arterioles which branch again to form the peritubular capillary network. The efferent arterioles of the juxtamedullary nephrons form long thin capillaries called vasa recta which traverse the medulla in a straight path and then loop back to the junction. The capillaries in the outer cortex and capsule of the kidney converge to form stellate veins. These veins drain into the interlobular veins.

The study was undertaken based on the hypothesis that if the polar arteries were to enter at the poles directly through the cortex would they contribute to a different kind of vascular architecture in the kidneys. Thus any variation in the histological features of kidneys with polar arteries could be documented for comparison with clinical conditions of kidneys like hypertension or polycystic kidneys.

METHODS

It was an observational study conducted in the department of anatomy, in collaboration with pathology department at P. E. S. Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh.

The study was conducted prospectively from July 2020 to September 2020 for a period of three months.

The study used specimens that were already dissected for the purpose of teaching medical students. Therefore it was a random collection of kidneys with polar arteries and demographic data was not applicable.

The study included only those kidneys which had arteries entering through the upper or lower poles. Kidneys which had accessory arteries that entered through the hilum were excluded.

Twenty-two kidneys with polar arteries were obtained from cadavers by the conventional dissection method. Sections were taken from the upper pole and lower pole in each kidney. In polar kidneys the sections were taken perpendicular to the axis of the course of polar artery and close to the polar artery. The sections were subjected to routine histological processing and staining as per the standard operating procedure. Histological findings were observed and documented. Each high power field corresponded with an area of 0.196 mm^2.

RESULTS

The study found that the kidneys were histologically different with polar arteries as compared to normal kidneys.

The number of glomeruli per high power field was higher nearer to the polar arteries. The glomeruli were viable and not sclerosed.

An agglomeration of arterioles were present close to the polar arteries but they were distinct and did not seem to be associated with glomeruli.

Table 1: Comparison of the histological findings of kidneys with polar arteries with normal kidneys without polar arteries.

Histological findings	Anatomy of kidney		
	Normal without polar arteries	**With upper polar arteries**	**With lower polar arteries**
Normal glomeruli	Present	Increased	Increased
Conglomerat-ion of arterioles	Nil	Present	Present
Cystic changes in tubules	Nil	Simple cyst, glomerular cyst and collagenou s cyst were seen	Nil.
Inflammatory changes	Nil	Chronic inflammato ry infiltrate in 15 cases	Nil
Sclerosed glomeruli	Present	Nil	Nil
Congestion	Present	Nil	Nil

There were 16 kidneys with upper polar artery. The findings were similar in all cases of the upper polar artery kidneys (Figure 1). The upper pole showed increased number of glomeruli with conglomeration of arteries around the polar artery. The tubules showed cystic changes.

A chronic inflammatory cell infiltrate was present in the interstitium in all cases except one case which showed an acute inflammatory cell infiltrate. There was one case of glomerular cyst, a case of simple cyst and one case of collagenous cyst.

One significant finding was there was no sign of congestion in any of the cases. There was no sclerosed glomeruli in any of the kidneys with upper polar arteries. There were six kidneys with lower polar artery. The findings were similar with increased number of glomeruli but as compared to upper polar kidneys the number was lesser.

The conglomeration of arteries was also lesser in the lower polar kidneys as compared to upper polar kidneys. There was no inflammatory cell infiltrate and no cystic changes in any case. There were no sclerosed glomeruli in any of the cases.

DISCUSSION

Variations of arteries entering the kidney have been documented in literature. In one such study by Ozkan et al they have described arteries dividing proximal to hilum as extra renal arteries (ERA).[1] They explained that extra renal arteries had two groups, one that entered through the hilum which are accessory arteries and the other that entered the capsule outside the hilum as aberrant arteries.

Ajmani et al studied intrarenal vascular segments of human kidney using corrosion cast technique.[2] They found that the branching pattern of anterior division of renal artery showed five different variations which could be grouped into 5 groups. The branching pattern of posterior division showed three different patterns. The posterior division was rarely absent. The apical segment showed many variations and they were grouped into seven types. Thus the segmental division of kidneys helps surgeons who have to decide on segmental or partial resection of kidneys. As per standard textbook descriptions of the vascular segments of kidney, the apical segment includes both anterior and posterior surfaces. The upper and middle anterior are confined to anterior surfaces only. The entire inferior pole constitutes the inferior segment. This also includes both anterior and posterior surfaces. Thus the arteries that enter through the upper pole or lower poles and thus called superior or inferior polar arteries could be considered additional apical or lower segmental arteries.

Kappel et al studied 54 human kidneys without renal disease obtained after death and 69 kidneys obtained by autopsy.[3] They measured the percentage of interstitial tissue by point count method. They observed that the relative number of sclerotic, obsolescent glomeruli was very small (0-1%) until the age of 40. It increased markedly in the autopsy series to 30%. Min et al first studied kidneys with increased vascularization at the polar region.[4] They made a three-dimensional analysis and found increased vessels around the vascular hilus in diabetic patients. Most of the new vessels arose from afferent arterioles. The authors opined that the small vessels served as shunts and facilitated efferent blood flow from the glomeruli. The present study was carried out with the hypothesis of extra vessels at the polar region (Figure 1) which could have a bearing on the arteriolo-capillary units. There is no information about the patient's history.

Figure 1: Gross photograph of kidney with polar arteries.

Stout et al in their study on diabetic glomeruli found that all extra vessels were connected to the efferent arterioles and drained into the peritubular capillaries.[5] They also assumed that the extra vessels decrease intra-glomerular pressure and might help preserve glomerular function, because the extra vessels contained muscle, identical to the efferent arterioles and thus did not block the glomerular outflow by anatomically hindering other arterioles in the vascular pole.

Sous et al studied 1,350 kidney biopsy specimens from patients with hypertension microscopically.[6] Along with parenchymal alterations they observed accompanying spasm of afferent arterioles. In one third of the cases they found arteriosclerosis. They quantified the total number of glomeruli, sclerosed glomeruli, and glomerular size. In the present study the number of glomeruli were seen to be increased along with an agglomeration of arterioles close to the section of polar artery (Figure 2).

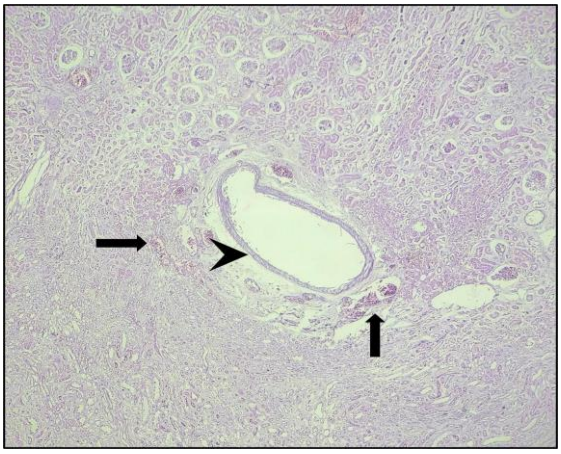

Figure 2: Microphotograph of kidney with polar artery displaying agglomerate of arterioles (arrows) around the polar artery (arrow head) (at 400X, H and E).

Patil et al have reported a case of inferior polar artery in their article and the surgical importance.[7] They discussed the importance of such a variation during renal transplantation procedures. With frequency of such variations a graft with multiple arteries may become a common procedure. To restore circulation in the accessory renal artery after surgery may be a challenging task for the surgeon, to avoid unnecessary ischemia or necrosis of renal tissue.

In another study by the present author a radiological study was conducted on kidneys with polar arteries.[8] The aim was to find out if there was any specific variation in the course or branching pattern of polar arteries that entered through the poles. The authors did not find any anastomoses of polar arteries with the other arteries in the segment where they entered. The polar arteries ended in the cortical region of the kidney. In a study by Aristotle et al the normal pattern of blood supply to the kidneys was

observed in 86.6% cases and variations were observed in the 13.4% cases.[9] However the study was not related to histological observation. Hatice et al studied renal artery variations in 820 patients using CT angiography.[10] Their aim was to trace the course of renal arteries from their origin. The study however did not report any histological observations. Cases et al had attempted to study renal artery variations by cadaveric and CT images.[11] They also classified the arterial patterns based on the origin of the arteries. Their study however did not include histological anatomy of the variations.

In a study by Rani et al the arterial pattern of kidneys was observed by angiography and corrosion cast techniques.[12] They described the segmental distribution based of anterior and posterior branches of renal arteries. They observed variations in the origins of segmental arteries. Their study did not include description of polar arteries and their branches. They also did not do a histological study as compared to the present study.

Shigueoka et al has described that preoperative study of renal arteries is indicated for evaluation of candidates for endovascular treatment of aortic aneurysms, using stent grafts.[13] The presence of polar arteries must be known to predict possible kidney injury. The polar arteries can be sacrificed if their caliber is small and the segment supplied by the polar artery is small. The present study has found a rich arterial aggregation near the branch of polar artery as can be seen (Figure 2).

Syah et al attempted to study the transplantation outcome in both donor and recipient outcome of multiple arteries allograft kidney compared with single renal artery kidney.[14] They concluded that transplantation with multiple arteries allograft had potential negative impacts on the recipient outcomes but was safe in donor outcomes. In the present study the arterial pattern was studied so that it could throw light on the complications during transplant surgery. Covantev et al studied the patterns of renal arteries by angiography using seldinger technique.[15] The study found out the variations in the renal arteries but the present study attempted to study histological pattern of the arteries.

Limitations

The study used regular haemotoxycilin and eosin stains only. No special stains were used for the study. It may be hypothesized that agglomeration of arterioles may be secondarily related to polar artery blood supply. The increase in number of glomeruli is a question for further exploration. The polar arteries may offer some protection to prevent sclerosis of glomeruli.

CONCLUSION

The study may be considered as a demystifying endeavour to recognize the histological features such as agglomeration of arterioles, increased number of viable glomeruli and cystic changes associated with kidneys having polar artery. It may be hypothesized that agglomeration of arterioles may be secondarily related to polar artery blood supply in the kidneys with polar arteries. The polar arteries may offer some protection to prevent sclerosis of glomeruli and there by preserve the viability of glomeruli.

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