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Original Research Article

A RADIOANATOMICAL STUDY ON CADAVERIC KIDNEYS TO TRACE THE COURSE OF POLAR ARTERIES TO KIDNEYS

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ABSTRACT

Introduction: The segmental arteries of the kidneys arise from the anterior and posterior divisions of the main renal artery. These segmental arteries branch into lobar and then into interlobar arteries. At the junction of the cortex and medulla they dichotomize into arcuate arteries. Interlobular arteries branch off at right angles from the arcuate arteries. The present study was attempted to find out the course taken by the polar arteries, whether they have a specific area of blood supply and whether they contribute to any anastomoses in the cortex with other arteries or whether they end in the cortex separately.

Results: 12 kidneys out of the 52 kidneys had arteries which entered the upper pole of the kidneys. The arteries that entered the upper poles took origin from the main renal artery proximal to the origin of anterior segmental artery and went to the poles directly from outside the hilum. The course of the artery was traced through radiological procedure and found that they entered the substance of the kidney and no traces of anastomoses could be made out. The terminal capillaries could not be traced in this particular method of study. Therefore it was not possible to find out if the polar arteries gave rise to interlobular arteries after they entered the poles of the kidneys.

Conclusion: The study did not find any anastomoses with the other arteries in the segment. The polar arteries ended in the substance of the kidney. Though it was not possible to trace if they divided into interlobular arteries in this study it has potential for research in the future to detect any disturbance in the kidney functions of those who have polar arteries. If the polar arteries were to end in the cortex would they contribute to a capsular network that results in increase in the formation of stellate veins which drain into interlobular veins and therefore increase the venous drainage of the kidneys? Will such an arrangement affect the counter current exchange mechanism?

KEY WORDS: Polar arteries, Segmental arteries, Anastomoses, Radioanatomical study.

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INTRODUCTION

The kidney has a segmental distribution of arteries. The kidneys are divided into five vascular segments. They are named apical,

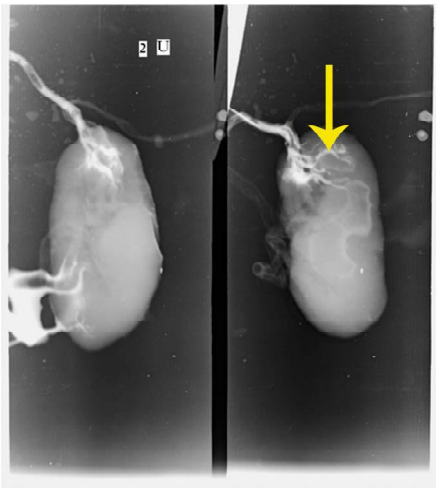
superior, middle, lower and posterior. These segments get their blood supply from the segmental arteries which arise from the anterior and posterior divisions of the main renal artery. These segmental arteries branch into lobar and then into interlobar arteries. At the junction of the cortex and medulla they dichotomize into arcuate arteries. Interlobular arteries branch off at right angles from the arcuate arteries. They course in the cortex perpendicular to the renal capsule. Interlobular arteries form the boundaries of 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 arterioles entering the medulla parallel the venules leaving it and form the counter current exchange mechanism [1].

This mechanism allows rapid removal of ions from the renal medulla. The close opposition of blood flowing in opposite directions allows direct diffusion of ions from out flowing to inflowing blood. The straight vessels vasa recta conserve the high osmotic pressure in the medulla. This is the normal course of arteries entering the kidneys at the hilum. Many authors have reported variations of arteries entering the kidney. In one such study by Ozkan et al [2] they have described arteries dividing proximal to hilum as Extra Renal Arteries (ERA). They explained that ERA had 2 groups one that entered through the hilum which are accessory arteries and the other that entered the capsule outside the hilus as aberrant arteries. These aberrant arteries entering outside the hilum through capsule will take a different course through the kidney. Therefore the study was undertaken based on the hypothesis that if the polar arteries were to end in the cortex would they contribute to a capsular network that results in increase in the formation of stellate veins which drain into interlobular veins and therefore increase the venous drainage of the kidneys? Will such an arrangement affect the counter current exchange mechanism? While there are many studies that have observed and discussed variations in the renal artery branches there are not many studies that have traced the course of the polar arteries in the kidneys. More research is needed in this area as this might significantly affect the renal circulation.

MATERIALS AND METHODS

Formalin fixed cadavers which were used for teaching purpose during routine dissection in P.E.S Institute of Medical Sciences & Research were used for the study. 52 kidneys from various cadavers were removed along with their arteries from their location. The arteries of the kidneys were then observed for variation in branching before entering the hilum, at the hilum and also entry at other points especially the poles. The kidneys with variations were photographed. The accessory arteries and aberrant arteries were noted and photographed. The kidneys with polar arteries were taken for the study. Urograffin a contrast material was used to inject into the polar artery of the kidney. After injecting the image of the kidney was taken. The radiograph was observed to see the course taken by the polar artery.

Fig. 1: Showing the polar artery in the cortex of the kidney.



RESULTS

It was observed that 12 kidneys out of the 52 kidneys had arteries which entered the upper pole of the kidneys. Of the 12, right side kidneys were 2 and left side kidneys were 10.

Of the 12 kidneys there were five left kidneys in which the posterior division gave duplicate and triplicate branches at the hilum. One left kidney had an artery that entered the lower pole of the kidney which was a direct branch from the aorta. The arteries that entered the upper poles took origin from the main renal artery proximal to the origin of anterior segmental artery. The arteries that branched outside the hilum showed fork and ladder patterns. The fork patterns were more frequent than ladder patterns. The branches from the anterior segmental artery were identifiable as apical, upper, middle, lower branches. Of the branches that were given by the posterior division one kidney had a branch that was directed upwards towards the upper segment at the hilum. The artery that was given off prior to the anterior segmental artery went to the poles directly from outside the hilum and the point of entry was not the same in all cases. There were different point of entry in different kidneys and no similarity at all. Therefore it was considered abnormal or aberrant. The course of the artery was traced through radiological procedure by injecting the radiocontrast urograffin. It was found that the polar artery ended in the cortical region of the kidney [Fig. 1] and not in the capsule as was expected. Therefore it seems that the artery has a course in the deeper parts of the kidney and could contribute to the peritubular network of capillaries in the cortex. In such a case the glomerular function could be affected with the blood supply pattern which is not a normal one as that which forms from the arteries that enter the hilum.

DISCUSSION

Ozkan et al [2] found in their angiographic study of 855 patients that 24% of patients had more than one renal artery. The right side had more than one artery compared to the left side. The occurrence of more than one artery on both sides was only 5%. They observed 71 aberrant and 69 accessory arteries on the right side and 58 aberrant and 58 accessory arteries on the left side. In the present study of the 12 polar arteries 10 were seen on the left and 2 on the right. The polar arteries took origin from the main renal artery (FIG-1) and can be considered normal segmental branching based on their origin.

Irena Vilhova et al [3] have described renal arteries as double, triple, accessory and perforating arteries. Double renal arteries originated from the aorta, were identical in diameter, blood supply areas, and gave branches that entered the hilum. The triple renal arteries varied in their diameters and areas of supply but branches entered the hilum. Accessory renal artery arose from the aorta, entered the hilum and supplied only one segment either upper or lower pole. A perforated renal artery originated from the aorta, entered the kidney outside the hilum and was comparable to a segmental artery supplying only one segment. The vessels which are aberrant are longer and narrower and the renal segments receiving these vessels have lower levels of blood pressure than the rest of parenchyma, thus increasing rennin secretion. They have opined that an anatomical reason could be the cause for disorders like hypertension and that there is a need to introduce terms for classifying plural renal arteries. In the present study the renal arteries that entered the kidney outside the hilum went to the upper pole and these were considered polar arteries because they arose from the main renal artery as a separate branch more proximal to the anterior division. They cannot be considered aberrant as they were from the main artery and they cannot be additional or accessory as they did not arise from the aorta and did not enter the hilum.

Saldarriaga, B et al [4] They have also observed that the renal pole was frequently supplied by the anterior division. They observed a direct branch from the renal artery-superior renal polar branch on the right-hand side in 17.2% and in 13.5% on the left hand side. The inferior polar branch was seen in 5 specimens each on the right and left sides. In the present study the superior polar branches were from the main renal artery and the inferior polar branch was seen in only one specimen on the left. This had taken origin from the aorta directly. So this can be considered an accessory artery to the lower pole.

Saldarriaga et al [5] observed additional arteries. The frequency of more than one additional artery was 87(22.3%) and 2 additional arteries was 10 (2.6%). They found that additional arteries had greater length than main arteries. The additional arteries ran parallel or divergent to

the main renal artery. They have also observed early ramification of the main renal artery and considered it important in diagnostic imaging and surgical complications during transplants. The first 15mm of the renal artery is used for anastomosis with the recipient's iliac artery. In the present study there was one kidney with an additional anterior segmental branch which gave the middle and lower branches.

Shoja et al [6] studied the variations in peri-hilar branching patern and morphology of the main artery. They classified the branching as ladder and fork patterns. The pattern where there was sequential branching points it was termed ladder type. The pattern with a common branching point was termed the fork type. The fork was either duplicate or triplicate depending on the number of branches. They divided their observations into cardinal peri-hilar morphology (more than 5%) and infrequent morphologies (less than 5%). They observed that the main artery was of the fork pattern in 92.6%, (75) duplicated in 80.2%(65) triplicated in 12.4%(10) and ladder pattern was 7.4%.(6). In the present study the fork pattern was seen in 42 kidneys and 4 kidneys had ladder pattern. There was no perihilar branching in only six kidneys. Therefore it can be considered that branching outside the hilum is a normal pattern where the arteries divide to go to the respective segments.

Julius A.Ogeng'o et al [7] have reported single, double, triple, and quadruple renal arteries. The double renal arteries were parallel, overlapped, initially superimposed then divergent and crossed types. Of the double arteries there were superior polar and inferior polar types. The single renal arteries were hilar, prehilar, and parenchymal branching types. The prehilar branching pattern showed terminal branches either before or after the hilum. The bifurcation pattern, fork and ladder patterns with overlapping of primary branches was observed. There were upto seven extraparenchymal branches reported in their study. In the present study the posterior division was observed to be having duplicate and triplicate branches in fork and ladder patterns in 11 kidneys.They can be considered extra parenchymal branches as the posterior division gives only one segmental branch normally.

Budhiraja V et al [8] also reported that superior polar arteries took origin from apical segmental branch in five out of the seven cases. In two cases they originated directly from the aorta. The present study found polar arteries arising from anterior segmental arteries. All the polar arteries entered outside the hilum and penetrated the capsule of the kidney.

Neerja Rani et al [9] identified variations in origins of segmental arteries. They observed the anterior division gave four branches apical, upper, middle and lower segmental arteries. In the present study the anterior division gave three branches and in 12 kidneys the polar branch as a separate branch from main renal artery.

Shinde Amol A et al [10] have reported from a study of 50 kidneys, lower polar supernumerary arteries in 4% of their specimens. They have cited the explanation given by Felix based on embryological development. The arteries supplying the kidneys of an 18mm fetus are from the dorsal aorta. There are nine pairs of arteries called the lateral mesonephric arteries. According to Felix the first two pairs are called cranial, the 3rd to 5th are called middle, and the 6th to 9th are called the caudal group. The middle group supplies the kidneys. If more than one artery persists then supernumerary arteries can result. There was only one lower polar artery in the present study.

A study by Marcelo Souto Nacif et al [11] describes the angiographic findings of 56 images . They concluded finally that imaging using MR angiography is significant in pre-transplantation evaluation for identifying abnormal vascular patterns. For renal vascular anatomy digital subtraction angiography is considered the best method.

Sampaio FJ, and Passos MA [12] discussed that radiologists play an important role in the anatomical evaluation of kidneys, emphasizing certain relevant findings prior to nephrectomy. They concluded that anatomical variants detected by a radiologist can enlighten the surgeon to avoid complications during surgical procedures especially live donor transplantation.

CONCLUSION

There is considerable potential and scope for research in this area and results can be correlated with clinical disorders of the kidneys in

patients. This study 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. Therefore it seems that the artery has a course in the deeper parts of the kidney and could contribute to the peritubular network of capillaries in the cortex. In such a case the glomerular function could be affected with the blood supply pattern which is not a normal one as that which forms from the arteries thatn enter the hilum. Though it was not possible to trace if they divided into interlobular arteries in this study it has potential for research in the future to detect any disturbance in the kidney functions of those who have polar arteries. If the polar arteries were to end in the cortex would they contribute to a capsular network that results in increase in the formation of stellate veins which drain into interlobular veins and therefore increase the venous drainage of the kidneys? Will such an arrangement affect the counter current exchange mechanism?

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Conflicts of Interests: None

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