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Original Article

A STUDY OF RENAL CALYCES BY USING BARIUM CONTRAST

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ABSTRACT

Objectives: To know the pelvicalyceal anatomy by radiological method that helps in localizing the calculi or tumors in kidneys.
Materials and method: The study was conducted in Sri Devaraj Urs Medical College, Tamaka, Kolar from 2011 to 2013. Forty four adult, formalin embalmed cadaveric kidneys (20 right and 24 left) were injected with 8 to 10 ml of 10% radio opaque barium sulphate solution into the renal pelvis and calyces and radiographs were taken in anteroposterior view.
Results: The observations were statistically analyzed. There were 14 extra renal pelves and 30 intra renal pelves. The major calyces were classified into three categories [Double (D), Three (T) and Multiple (M) divisions]. Out of 44 kidneys 20 were right and 24 left.. 23 kidneys presented multiple (more than 4) calyces, 12 had two major calyces and only 9 presented with three major calyces). Typical 'Y' arrangement in 03 out of 12 and typical multiple in 03 out of 23 kidneys. There were 14 kidneys (31.8%) presented with extra renal pelvis whereas 30 kidneys (68.2%) presented intrarenal formation of the renal pelvis.
Conclusion: Due to the variation in the number of major and minor calyces, position of renal pelvis (intrarenal and extra renal), the knowledge of pelvicalyceal anatomy will help the urologist and nephrologists to pin point the position of renal calyceal calculi or malignant growth for the surgery to be carried out.
KEYWORDS: Renal pelvis, renal calyces, Ureter, Kidneys, Barium sulphate, contrast radiography.

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BACKGROUND

The renal sinus, present at the renal hilus, is filled with renal vessels and renal pelvis; and is lined by the capsule of the kidney. All these structures are surrounded by supporting connective tissue and fat. The renal collecting tubules of the nephrons join to form collecting ducts which open on the summit of the renal papillae. The renal papillae are surrounded by funnel shaped expansions called minor calyces. Adjacent minor calyces join to form two to three major calyces. The minor calyces receive the ducts of single papilla or adjacent 2 to 3 papillae. There are seven pairs of calyces in each kidney which are ventral and dorsal. These calyces drain into two or three infundibula or major calyces, which drain into a funnel shaped renal pelvis. When there are two infundibula the upper three pairs drain into upper infundibulum which drain

the upper pole of the kidney and the lower four pairs drain in to lower infundibulum which drain the lower pole of the kidney. When third infundibulum is present it drains the middle part of the kidney. The distribution of calyces in that case will be - three pairs into upper, two into the middle and two into the lower infundibula which drain upper pole, middle part and lower pole of the kidney. The renal pelvis thus formed will taper and continue as ureter from the lower and medial aspect of the renal sinus. The calyces are normally cup shaped and are demonstrated in contrast radiography called excretory urogram or ascending pyelogram. The cupping of the calyces is obliterated and may reverse to become club shaped whenever there is an increased intrapelvic pressure in kidney as in hydronephrosis [1].

The development of the renal pelvis and calyceal system are from the ureteric bud of the mesonephric duct. The ureteric bud undergoes repeated branching and forms various generations of collecting tubules. The first four generations of division of tubules enlarge, fuse and form major calyces or infundibula. The next four generations join to form minor calyces. The remaining branches remain as collecting ducts [2].

The developmental anomalies of the kidneys and the variations associated with the collecting system of ureters are many. The number of minor calyces and their position are subjected to number of variations and same is in case of infundibula; there may be absence of one or all the infundibula or there may be elongated infundibula. The minor calyces vary from 5 to 20 but about 8 to 9 minor calyces are seen in normal adult kidney. In fetal life the minor calyces are divided into anterior and posterior divisions which are fused in upper and lower parts whereas they remain separate in the middle part. The maximum fusion takes place in the upper part and minimum in lower part of kidney in the last trimester of gestation and become the adult form. According to Edward et al there are two types of renal pelves – intrarenal and extra renal. It was also noted that the extra renal was larger than the intrarenal pelvis. The extra renal pelvis is associated with small sized kidney, occasionally the pelvis cannot be demonstrated as it is of the same caliber as that of ureter[3].

There is another classification in which the major calyces are long with a small renal pelvis and short major calyces with large renal pelvis. Depending upon the arrangement, shape and prominence of calyces and of pelvicalyceal parts. Graves (1986) classified into two primary and two intermediate types. The intermediate gradation consisted of four subtypes – type A consists of classic Y shape, type B is like inverted T, type C is the balloon type and type D is like inverted bagpipe. According to Sampaio (1993) there are A and B types which are further divided into A-I, AII, BI and BII. In AI type the major calyx from superior and inferior pole represents primary division of renal pelvis and radial arrangement of minor calyces. In A-II type the upper and lower major calyces draining the mid zone cross each other. In BI type the groups of minor calyces drain into middle major calyx and in type BII, multiple minor calyces draining the mid zone and join the renal pelvis at many points [4,5].

Many authors have also noted various ureteric anomalies along with the pelvicalyceal arrangements and various vascular anomalies like the accessory, aberrant renal arteries and accessory and aberrant renal veins [6].

Some patients presented with problems in case of variation in the pelvi-calyceal junctions which caused hematuria without any altered appearance of the pelvicalyceal junction [7].

The pelvicalyceal arrangement in the kidneys might lead to the formation of kidney stones if the renal pelvis is wider and if there are more number of branches present. Wider calyx and lower level placement are the factors which lead to improper drainage and allow stagnation that will lead to formation of a nidus or nucleus for stone formation [8].

The knowledge of the arrangements of calyces, plane in which they are situated and their number is important which helps in decreasing the complications during localization of the stone bearing calyx while performing the percutaneous nephrolithotomy [9].

In the present study on adult cadaveric kidneys, about 8 to10 ml of barium sulphate solution was

injected through the proximal ureters irrespective of the side and the sex. Radiographs of those kidneys were taken in anteroposteriorview.

MATERIALS AND METHODS

During routine undergraduate dissection of formalin embalmed adult cadavers, irrespective of sex, 44 kidneys along with proximal ureters were removed by dissection method at Sri Devaraj Urs Medical College, Tamaka, Kolar during the period of three years (2011 to 2013).

All 44 kidneys were injected with 10 ml of barium sulphate solution prepared by dissolving 3 to 5 Gms of barium sulphate in 10-15 ml of water. It was injected in to the renal pelvis and calyces through the cut end of the proximal ureter by using 10 ml syringe. These kidneys were radiographed using Siemens machine 300ma/10 inches / 8 inches with CR system.

Inclusion criteria: all the normal adult kidneys which had patent calyceal system.

Exclusion criteria: kidneys with developmental anomalies, accessory or aberrant renal vessels, anomalous ureters, ectopic kidneys, malrotated kidneys, kidneys associated with tumors were excluded. The kidneys in which the dye did not enter due to the block and which were sectioned coronally to study the interior, were also excluded from the study.

OBSERVATIONS AND RESULTS

Total of 44 (20 right and 24 left) kidneys were studied. (Table 1)

In 14 out of 44, there was **extra renal** formation of renal pelvis and remaining 30 had **intrarenal pelvis** within the renal sinus.

Out of the 30 **intra renal pelves**, 14 (46.66%) were on the right side and 16 (53.33%) were on the left side.

Out of the 14 **extra renal pelves**, 06 (42.85%) were on the right side and 08 were on the left side ((57.14%). (Table 2)

Table 1: The side of the kidneys for the study.

Side of kidney	Total No.
Right	20
Left	24
TOTAL	44

The number of major calyces were classified into D= double (D), T = Three M = Multiple divisions.

23 kidneys presented **multiple** (more than 4) calyces (52.27%), 12 had **two (double)** major calyces ((27.27%) and only 9 presented with t**hree** major calyces (20.46%). (Table 3)

Typical 'Y' arrangement in 03 out of 44 and typical multiple (M) in 03 out of 44.

Table 2: Side distribution of intra and extra renal pelves.

Position of the renal pelvis	Side of the kidney (renal pelvis)		Total
	Right	Left	
Intra renal	14 (46.66%)	16 (53.33%)	30 (68.18%)
Extra renal	06 (42.85%)	08 (57.15%)	14 (31.82%)
Total	20	24	44

Table 3: Classification depending on the branches of major calyces.

Two branches (D)	Three branches (T)	Multiple branches (M)
12 (27.27%)	09 (20.46%)	23 (52.27%)

Fig. 1: Double (D) major calyces.

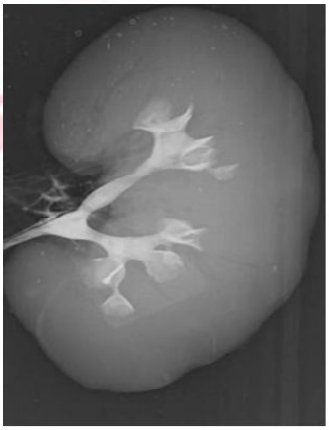

Fig. 2: Three (T) major calyces.

Fig. 3: Multiple (M) major calyces.

Fig. 4: Extra renal pelvis.

Fig. 5: Intrarenal pelvis.

Fig. 6: Typical Y- shaped arrangement of the pelvicalyceal part.

Fig. 7: Typical multiple calyces.

DISCUSSION

Renal calyces are cup shaped structures present at the apices of the pyramids. There are minor calyces and major calyces. At the apex of the pyramid many papillary ducts open which are formed by the union of many collecting ducts. The minor calyces are the cup like dilatations seen at the apex of one or more pyramids that receive the papillary ducts. The number of minor calyces, therefore, do not correspond the number of pyramids. Many minor calyces join to form 2 to 3 major calyces. The structure of the papilla is continuous with that of the minor calyx. The volume of the calyces and the pelvis of the kidney is approximately estimated as 8 to 10 ml [10,11].

The development of the calyces is from the ureteric bud which branches and rebranches to form the calyceal system which finally gives rise to the collecting ducts [2].

The kidneys develop from two sources – the excretory part is from metanephric mesoderm and the collecting part is from the ureteric bud arising as an outgrowth from the mesonephric duct which is again mesodermal in origin. The ureteric bud gradually dilates to form the renal pelvis. The renal pelvis now divides into cranial and caudal parts to form the future major calyces. Each major calyx keeps on dividing till 12 or more generations of divisions as they are penetrating into the metanephric blastema. This occurs till the 5th month of fetal life. As the branching is taking place, the second orders of division absorb the third and the fourth generations of divisions to form minor calyces.

A transcription factor, expressed in the metanephric blastema called the WT1 (Wilms Tumor Factor 1) and GDNF (Glial Derived Neurotropic Factor) stimulate the branching and growth of the ureteric buds. The mesodermal cells of the ureteric bud in turn secrete many other factors which help in the formation of nephrons and their communication with the collecting part of the kidney [12]. Each kidney consists of about 7 pairs of calyces. They are ventral and dorsal.

These calyces drain into two or three infundibula (major calyces) which drain into a funnel shaped renal pelvis. The infundibula are formed by the union of minor calyces. When there are two infundibula the upper three pairs drain into upper infundibulum which drain the upper pole of the kidney and the lower four pairs drain in to lower infundibulum which drain the lower pole of the kidney. When third infundibulum is present it drains the middle part of the kidney. The distribution of calyces in that case will be three pairs into upper infundibulum, two into the middle and two into the lower infundibula which drain upper pole, middle part and lower pole of the kidney [1].

Depending upon the arrangement, shape, prominences of calyces and of pelvi calyceal parts they were divided into 'Y' (type A), 'T' (type B), balloon shaped (type C) and inverted bagpipe (type D). Sampaio further classified the minor calyces into AI, AII, BI and BII depending upon the division, arrangement and the area (lobe) of drainage [4,5].

In the present study barium sulphate solution was injected into the renal pelvi calyceal system through the cut end of the ureter at pelvi ureteric region. Radiographs were taken in anteroposterior view. The observations were made depending upon the number of calyces, position of the renal pelvis in relation to the renal sinus (intra renal or extra renal) and the distribution on the right and left sides.

Out of 44 kidneys 20 were right and 24 were left kidneys. (Table 1).

In 14 out of 44 ((31.8 %) there were **extra renal** formation of renal pelvis (Figure4) remaining 30 (68.2%) had **intrarenal pelvis** within the renal sinus. (Figure5)

Out of the 14 **extra renal pelves**, 06 (42.85%) were on the right side and 08 (57.14%) were on the left side. Out of the 30 **intra renal pelves**, 14 (46.66%) were on the right side and 16 (53.33%) were on the left side. (Table 2)

The real calyces were also studied depending upon the branching pattern (Table 3).

12 had **two (double)** major calyces (D) (27.27%) (Figure1) and only 9 presented with t**hree** major calyces (T) (20.46%) (Figure2) 23 kidneys presented **multiple** (more than 4) calyces (M) (52.27%) (Figure3).

Typical 'Y' arrangement (Figure6). In 03 out of 44 kidneys (6.85%). Typical multiple in 03 out of 44 (6.8%) (Figure7).

Some authors have studied the formation of the renal pelvis, whether it was intra renal or extra renal. In the present study there were 14 kidneys (31.8 %) presented with extra renal pelvis where as 30 kidneys (68.2%) presented intrarenal formation of the renal pelvis. This coincided with the previous authors. The extra renal pelves of kidneys were larger where as the intrarenal pelves were smaller. In some, the intrarenal presented only minor calyces [4].

It was earlier thought that the lower calyces have the tendency to develop renal pelvic calculi due to stagnation and impairment in draining the urine as it was attributed to the gravitation. But it is now thought that along with the anatomical position, if there are metabolic factors associated, then there are more chances of formation of renal stones [8].

The contrast radiographs of the cadaveric kidneys were taken only in anteroposterior view. Therefore it was difficult to visualize the anterior and posterior branches of the major calyces as there will be overlapping of the shadows. It requires three dimensional endocasts, by doing serial cross sectional visualization of the kidneys by CT or MRI. The knowledge of the planes in which these calyces are arranged will definitely help in pin pointing the exact position of renal calculi or malignancy. The other inability to visualize the calyceal system in one plane is that the kidneys are situated in the posterior abdominal wall obliquely in relation to Psoas major muscles making an angle of 30 to 45 degrees in supine position. Therefore in intravenous pyelograms (excretory urograms) the anterior calyces appear more peripherally than the posterior calyces which are visualized on the medial aspect. This is called Brodel type of kidney. On the other hand if the contrast radiographs of kidneys are taken in prone position the anterior calyces are placed 20 degrees with frontal plane where as posterior calyces lie 70 degrees to frontal plane. This is called the Hudson type. But in both types the

relative position of the calyces did not change significantly. The knowledge of situation of kidneys, the position of the kidneys in relation to Psoas major muscle, the number and arrangement of the calyceal system and their plane of situation helps in repositioning the patient on the operating table and positioning the fluoroscope in case of percutaneous nephrolithotomy in calyceal stones.. The three dimensional accuracy in positioning of the kidney helps in preventing the intraoperative hemorrhage and its complications [9,5].

CONCLUSION

The kidneys consist of excretory part and collecting part. The collecting part of the kidneys consist of collecting ducts, minor calyces, major calyces and the renal pelvis which continues as ureter. In the present study 44 kidneys (20 right and 24 left) were obtained from the dissected cadavers and about 8 -10 ml of diluted radio opaque barium sulphate solution was injected into the renal calyces and renal pelves through the cut end of the pelvi ureteric region. Radiographs were taken in anteroposterior view. The observations were statistically analyzed. There were 14 kidneys (31.8 %) presented with extra renal pelvis where as 30 kidneys (68.18 %) presented intrarenal formation of the renal pelvis. There were 14 extra renal pelves (31.82%) and 30 intra renal pelves (68.18%). The major calyces were classified into three categories [double (D), Three (T) and Multiple (M) branches].

23 kidneys presented multiple (more than 4) calyces, 12 had two major calyces and only 9 presented with three major calyces. Typical 'Y' arrangement in 03 out of 12 and typical multiple in 03 out of 23.

A transcription factor, expressed in the metanephric blastema called the WT1 (Wilms Tumor Factor 1) and GDNF (Glial Derived Neurotropic Factor) stimulate the branching and growth of the ureteric buds. The knowledge of the pelvi calyceal anatomy in kidneys in relation to the arrangement of the minor and major calyces, variation in the number, position and presence of intra renal or extra renal pelves is important clinically because huge number of developments have taken place in fields of endourology, percutaneous nephrolithotomy and various similar procedures.

Conflicts of Interests: None

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