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A study on the Anatomical Variations in the Formation of Renal Pelvi-calyceal System in Population of Northeast India

Mousumee Saikia [a,*], Rajat Dutta Roy [b], Debabani Bora [a]

[a] *Department of Anatomy, Jorhat Medical College & Hospital, Jorhat, Assam, India*
[b] *Department of Anatomy, Nogaon Medical College, Nagaon, Assam, India*

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ABSTRACT

Background and aim: The renal pelvicalyceal system consists of the renal pelvis and the two groups of calyces – the major and the minor. Wide variations in the formation of this system have been reported earlier. The study aimed to provide a clear picture of the morphology as well as the anatomical variations associated with the human renal pelvicalyceal system in the Northeast Indian population that can help to minimize injuries and complications associated with various surgical and radiological interventions in this region.

Material and methods: The study was conducted on 160 formalin-fixed specimens collected after dissection from adult and perinatal cadavers above 36 weeks of age. All the specimens were numbered accordingly, and piecemeal dissection was done.

Results: The study showed a predominance of the intrarenal pelvis, with the bicalyceal arrangement of major calyces being more than the tricameral pattern. 89.37% of specimens showed normal patterns as described by standard textbooks and authors of previous studies. Meanwhile, 10.62% of specimens had unusual variations, mainly on the right side. These include the absent pelvis, bifid pelvis, absent major calyx, mega calyx, elongated superior calyx, thick major calyx, four major calyx, and dilated calyces. The most commonly occurring variation was absent major calyx (3.75%), followed by absent pelvis (2.5%) and megacalyx (2.3%).

Conclusions: The study showed that the renal pelvicalyceal system exhibits various variations. Proper knowledge of these structures' normal and variant anatomy is the key to safe radiological and urological interventions.

1. Introduction

The renal pelvicalyceal system includes the renal pelvis and calyces – the major and the minor. The minor calyces vary widely in number from 5 to 20. These minor calyces unite with their neighbours to form 2 to 3 significant calyces. Major calyces, in turn, fuse to form the renal pelvis.[1] However, numerous kidney developmental anomalies and variations in the collecting system are observed, primarily resulting from defects in development. The renal pelvicalyceal system is classified according to its location, shape, position, length, and the pattern of drainage of calyces. The renal pelvis was classified into intra-renal, extra-renal, and mixed pelvis. It was stated that there were three types of pelvis: ampullary, intermediate, and bifurcated.[2-5] Gómez et al.,[6] classified renal pelvis based on the length of calyces as long and brachy types. Cicek et al.,[4] and Ningthoujam et al.,[7] The pelvicalyceal system is classified into multicalyceal, tricalyceal, and bicalyceal types. Takazawa et al.[8] classified it into a single and divided pelvis. Those patterns that do not fit the above types are grouped as unclassified. However, not much literature regarding this is available in this region. Thus, the present study attempts to contribute to existing knowledge in this field and thus benefit surgeons in safe surgery.

2. Material and methods

This cross-sectional cadaveric study was conducted in the Department of Anatomy, Assam Medical College and Hospital(AMCH), Dibrugarh, Assam, India. A total of 160 specimens were included in the study. Out of these, 15 were from adult cadavers (11 male, 4 female), and 65 were from perinatal cadavers (28 male, 37 female) that were over 36 weeks of age brought from the Department of Obstetrics and Gynaecology, AMCH, Dibrugarh. The specimens were used in the study after routine dissection of the abdominal cavity by medical graduates. Ethical clearance was taken from the Institutional Ethics Committee (H) before data collection. (No. AMC/EC/PG/13/12742).

* Corresponding author. *Mousumee Saikia*
E-mail address: drmousumee2@gmail.com
Department of Anatomy, Jorhat Medical College & Hospital, Jorhat, Assam, India
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Exclusion criteria

Cadavers excluded from the present study are:

Perinates before 32 weeks of gestation and weight < 2 kg.
Cadavers with gross congenital malformations.
Cadavers with a record of renal surgery.
Cadavers with wound scars or trauma in the abdominal lumbar region.
Specimens having any pathology distorting the shape of the kidney or renal pelvis.

The adult cadavers have been embalmed with embalming fluid by gravity method using 40% formalin. The fetal cadavers were dissected immediately, and specimens collected from them were preserved in a jar containing 10% formalin for 15 days.

Method of Dissection

The abdomen was opened by a median longitudinal incision on the anterior abdominal wall, and the intestine was retracted superiorly. First, the psoas major muscle, the pelvis, and the ureters were identified. Kidneys, ureters, and urinary bladder were dissected after reflecting the posterior abdominal wall's peritoneum and removing renal fascia. The specimens were washed thoroughly in running tap water and transferred to a jar containing 10% Formalin. The renal vessels and loose areolar tissues from both the anterior and posterior surfaces of the renal pelvis were removed and cleaned. The specimens were numbered, and the midsagittal section of the kidneys was taken to secure most of the part of the renal collecting system. The renal pelvis was examined to determine whether it is extra-renal, juxtarenal, or intrarenal. The pelvis was traced to the major and minor calyces after sectioning anteriorly close to the pelvis. Piecemeal dissection was done to delineate the positions of calyces. The branching pattern of the major and minor calyces was studied.

Statistical analysis

The data collected from the study was recorded. The results and observations were evaluated using tables and statistical diagrams wherever applicable. Fisher's exact test was performed to see if there was any association between categorical variables. A P-value less than or equal to 0.05 was considered significant.

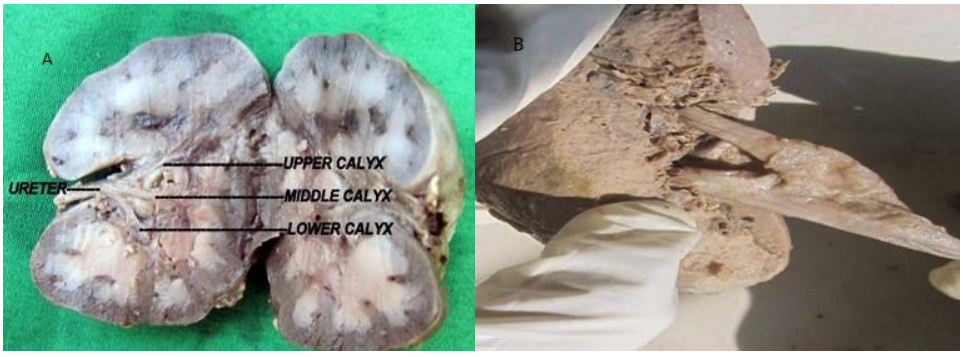
3. Results

No. of Renal Pelvis

In the study, 96.25% (n=154) of specimens showed normal single pelvis. The pelvis is found to be absent in 2.50% (n=4) of cases (Fig. 1A) (Table 1). An unusual case of bilateral bifid pelvis [Fig. 1B] was observed in one of the adult male specimens. A right-sided double pelvis was found in the perinatal female specimen.

Table 1. Number of pelvis.

Number	Right		Left		Total
	Male	Female	Male	Female	
1	37	39	38	40	154(96.25%)
2	1	1	1	0	3(1.88%)
>2	0	0	0	0	0
Absent	1	1	0	2	4(2.50%)



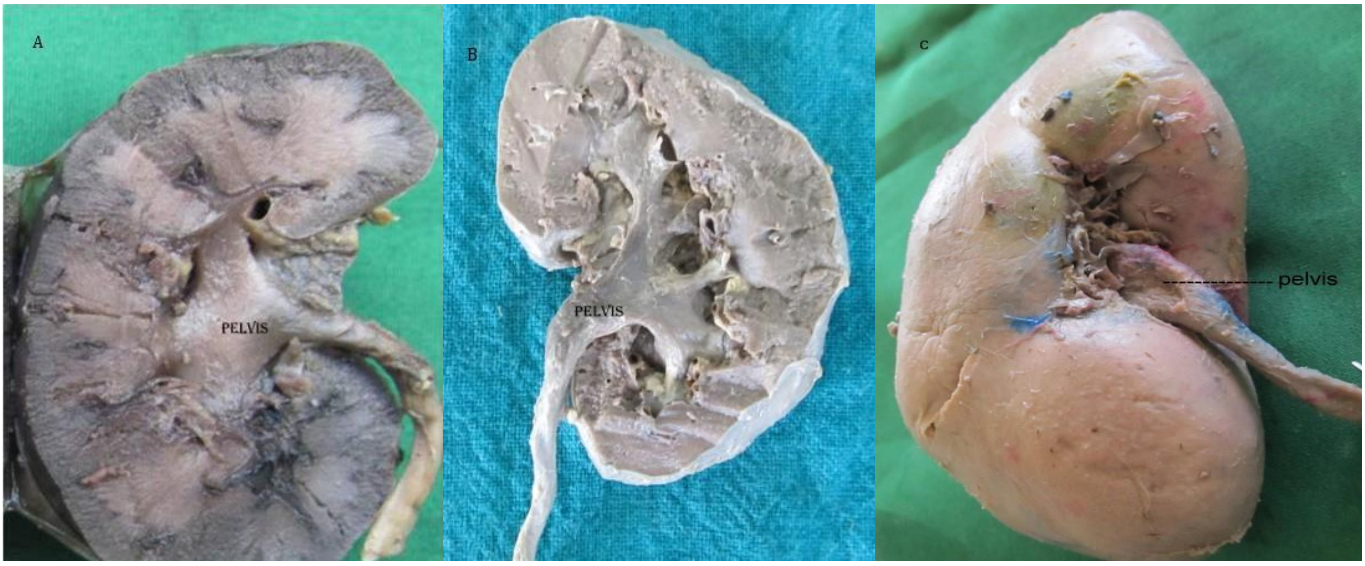
Figs. 1. (A) Absent Pelvis. (B) Bifid Pelvis.

Positions of Pelvis

In the present study, a total of 55.17% of adult cadavers show intrarenal pelvis. A total of 41.37% showed extra-renal and 7.1% juxtarenal pelvis. Only one adult specimen showed an absent pelvis on the right side, which was excluded during the calculation. Among the perinatal cadavers, 81.74 % of the pelvis were intrarenal, 10.31% were extra-renal, and 7.93% were juxtarenal. In both adults and perinates, the incidence of intrarenal type was higher on the left side- 60% and 82.8%, respectively.(Table 2, Figs. 2A, 2B, 2C) The intrarenal pelvis was more common in both age groups, more on the left side.(p=0.003) (Table 2). The juxtrarenal position of the pelvis was found to be less in both age groups.

Table 2. Age-wise distribution of the position of the pelvis.

Position of Pelvis	Perinate (n=126)	Adult (n=29)
Intrarenal	103(81.7&)	16 (55.1%)
Extrarenal	13(10%)	12(41.3%)
Juxtrarenal	10(7.9%)	1(3.4%)



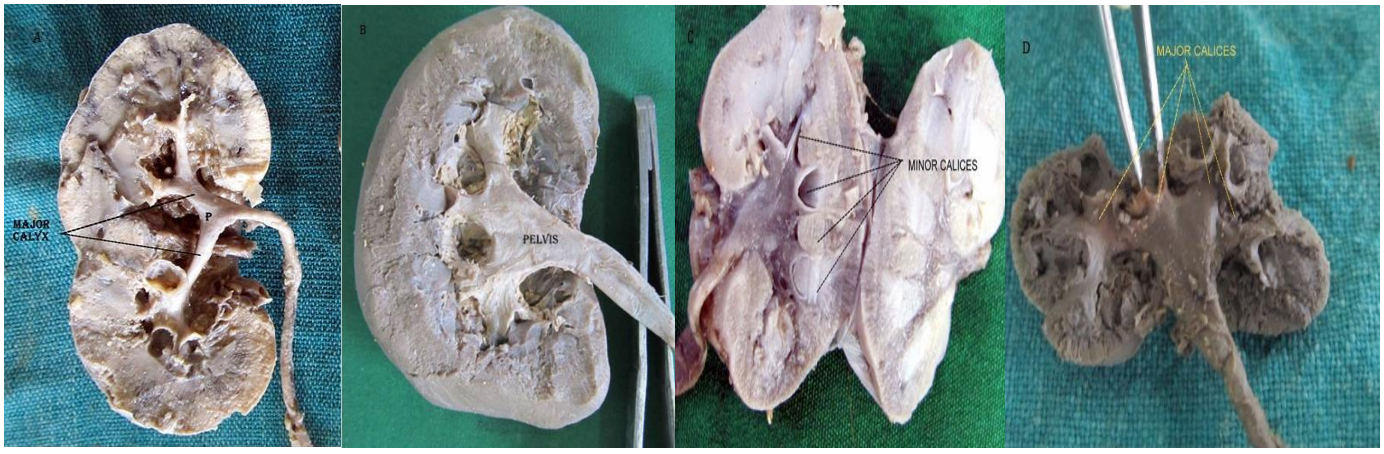
Figs. 2. (A) Intrarenal pelvis, (B) Juxtrarenal pelvis, (C) Extrarenal pelvis.

Types of Calyceal System depending upon major calyces and midzone minor calyces

In the present study, various numbers of major calyces were found. (Figs. 3A, 3B). Major calyx was absent in 3.75% of cases (Fig. 3C), and 0.63% had four major calyces (Fig. 3D). In this study, the bi-calyceal type was more common than the tri-calyceal type(Table 3). However, bicalyceal and multicalyceal (2 major calices with multiple midzone minor calices) types had no significant distribution variation among the two age groups. (Fig. 4B)

Table 3. Showing the number of major calyces.

Bicalyceal	73(45.6%)
Tricalyceal	68(42.5%)
Multicalyceal (2 major calices with multiple midzone minor calices)	12(7.5%)
Absent major calyx	6(3.75%)
Four major calyces	1(0.63%)



Figs. 3. (A) Bicaliceal, (B) Tricaliceal, (C) Absent major calyx, (D) Four major calices.

Distribution of minor calyces

In the present study, 63.75% of total specimens showed 6-10 minor calyces and 30.63% showed 11-15 minor calyces. Only 1.88% of cases have shown 16-20 numbers of minor calyces. 12 (7.5%) specimens showed crossing over of minor calyces of midzone to drain into upper and lower major calyces.(Fig. 4A) It occurred more on the right side in adults and on the left in perinates. Both age groups showed female predominance. 7.5% midzone minor calices (multicaliceal) drain directly to the pelvis. (Fig. 4B).

Figs. 4. (A) Midzone minor calices to drain into major calices. (B) Crossing over of midzone minor calices draining directly into renal pelvis(multicaliceal).

Variations in the renal pelvicalyceal system

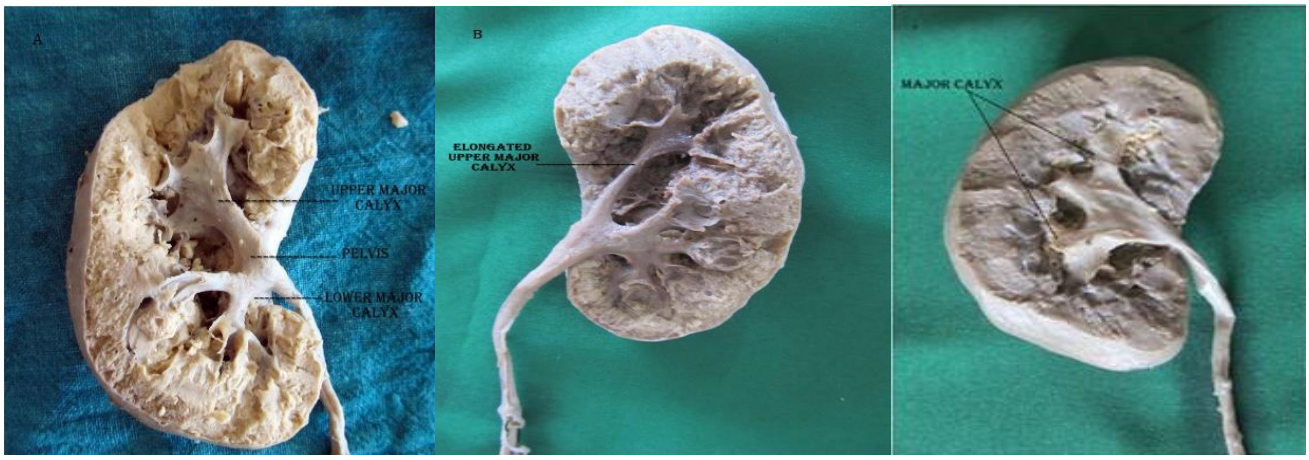
One hundred and forty three (89.37%) specimens showed a normal pattern of the renal pelvicalyceal system, whereas 17(10.62%) specimens showed unusual variations. Unusual variations included absent major calyx (n=6), four major calyx(n=1), megacalyx(n=2), elongated major calyx(n=2), thick major calyx(n=2), absent pelvis(n=4), bifid pelvis(n=2). (Figs. 3C, 3D, 5A, 5B, 5C, 1A, 1B) No statistically significant associations of normal and unusual variations with either age group existed.

The number of minor calyces

The number of minor calyces in the present study varies between 4 and 16. This finding correlates with the available literature.[1, 8, 27, 28] minor calyces are more common in perinatal specimens than adult specimens, as minor calyces are merged in adults during maturity. Several minor calices in the operating field result in a success rate of PCNL and less invasive endoscopic procedures.

Unusual variations of the pelvicalyceal system

Unusual variations of the pelvicalyceal system were seen in 10.62% of specimens, mostly on the right side. These include absent pelvis(2.5%), bifid/double pelvis(1.25%), absent major calyx(3.7%), megacalyx(2.3%), elongated superior calyx(1.25%), thick major calyx(1.25%), 4 major calyx(.62%) and dilated calyces(1.25%). Megacalyx was reported 17.3% by Gandhi et al.,[13] Absent major calyx was reported by Sebe et al.,[27] Qi Y et al.,[25] Cicek et al.,[4] was- 3%, 12%, and 20.7%, respectively. Sampio et al.,[29] mentioned two unusual varieties of pelvicalyceal system with a long and thin superior calyceal infundibulum and another with a short and thick superior and inferior calyceal infundibulum.[23, 29](Dilated renal pelvis (Megacalyx) was observed in 17.3% by Gandhi et al.,[13] In the present study, only 1.25% show bilateral bifid pelvis. A cadaver with a right-sided double pelvis (0.62%) is also observed, which is less than that of 10. Mittal et al.,[10] (4%) but more than Ntalianis et al.,[11] who reported the incidence of double pelvis as 0.7%.



Figs. 5. (A) Mega calyx (superior), (B) Elongated superior calyx, (C) Thick major calyx.

4. Discussion

Knowledge of the pelvicalyceal system is essential to provide effective treatment and investigative procedures to diagnose urological pathologies. The availability of literature regarding the percentage of various pelvicalyceal patterns in this part of the country is meager. Since the study was conducted in cadaveric kidney specimens, all types of patterns, including the crossing calyces pattern, are identified, which can otherwise be misinterpreted in radiological studies as a single calyx, as they appear to superimpose on each other. In the present study, 96.25% of specimens showed a normal single pelvis, and 2.5% had an absent pelvis, similar to the studies reported.[2, 4, 7, 9] The incidence of duplication of the pelvis in the present study (1.88%) is less than that reported by Mittal et al.,[10] but more than that of Ntalianis et al.[11](0.7%). The most common position of the renal pelvis was found to be intrarenal in the present study (55.1% and 81.7%, respectively, in adults and perinates). This is similar to studies carried out elsewhere.[5, 9, 13, 21] In our study, the extra-renal pelvis was 41% in adults and 10% in perinates. Whereas Cicek et al., Anjana et al., and Gandhi et al. reported extra-renal pelvis as 5%, 6.1%, and 21.9%, respectively[4, 9, 13] and the incidence of extra-renal pelvis quoted in literature is around 10%.[14] Borderline / juxtrarenal pelvis was reported at 13.4% by Cicek et al.,[4] Earlier, Sykes 1963 studied details of the location of the renal pelvis in 240 kidneys and found only 12 (5%) of these possessed extra-renal major calyces.[15] Clinically, the extra-renal pelvis is roomier and more convenient to explore during nephron-sparing surgery and partial nephrectomy than the intra-renal pelvis because it provides a larger surface area away from the renal vasculature for safe surgery. However, the drawback is that the larger pelvic space aggravates urine accumulation and stasis, predisposing renal calculi formation.[16] A distended renal pelvis and collecting system facilitate the puncture, placement, and maneuvering of the endourologic instruments and, by providing a larger fluid chamber around a stone, enhance the efficacy of ESWL.[17-19] Tubaro et al.[20] in their retrospective study on 255 patients who have undergone partial nephrectomy, concluded that the intra-renal pelvis is smaller and associated with longer, thinner infundibula. The intra-renal pelvis was also associated with complications such as urine leak presence. A completely intra-renal pelvis is confined within renal parenchyma and constrained to a smaller volume. Fluid dynamics by Pascal's principle and Laplace's law explain the preferential leak rate of the intra-renal pelvis. The smaller surface area of the intra-renal pelvis is responsible for increased wall tension or intra-renal pressure in cases of ureteral obstruction. It portends a urinary leak following partial nephrotomy found in 48.4% of specimens.[13] Our study observed that the intrarenal pelvis is formed by both significant minor calyces, which contradicts the findings of Grevious et al.[21] who stated that the intrarenal pelvis is formed only by minor calyces. The pelvis of a few specimens was found to be similar to the ampullary type, where the pelvis is large and significant calyces are short (Brachi type), and ramified type, where major calyces are long (long type), ending in a small pelvis. These findings are similar to the study done by Sokołowska-Pituchowa et al.[3] Piasecki et al.[22] Zerdan.[6] Gómez.[5] and Zhu W et al.[23] The knowledge of detailed calyceal anatomy is essential for performing urologic procedures such as percutaneous nephrolithotomy, percutaneous nephrostomy, flexible ureterorenoscopy, endopyelotomy, and retrograde intrarenal surgery. It is also essential for indicating and predicting the extracorporeal shock wave lithotripsy (ESWL) outcome for treating lower pole nephrolithiasis. The present study observed that the bicalyceal type was more common than the tricalyceal type, similar to studies worldwide studies.[4, 9, 12, 13, 24, 25] Ningthoujam et al.[7] found the incidence of the tricalyceal type (40%) was higher than bicalyceal type, which is not similar to the present study. The pelvis is less spacious in the bicalyceal or Y-shaped type, with a long infundibulum. The upper and lower significant calyces are formed by the convergence of 4-5 minor calyces draining from all aspects of the poles. Incidence of crossing over of midzone minor calyces is seen in 7.5% of the specimen, which is almost similar to the findings of Ningthoujam et al.[7] Kawase et al.[26] observed that pelvicalyceal system anatomy plays a role in both upper calyceal stone formation. The success of the endoscopic combined intrarenal surgery (ECIRS) procedure as the stone formation rate in the bicalyceal pelvis was significantly lower than that in the multicalyceal /single pelvis.

5. Conclusion

This cadaveric study showed that the renal pelvicalyceal system exhibits a broad spectrum of variations in the Northeastern region of India. The most common variety observed in this study is the intrarenal pelvis and bicalyceal type of pelvicalyceal system. This kind of pelvicalycial system is less prone to stone formation but has more chances of complications like urine leakage after surgery. 10.62% of specimens had unusual variations, mainly on the right side. The Surgeons and radiologists will have the advantage of interpreting the diagnostic imaging findings by knowing such variations.

Conflict of Interest

The authors declared that there is no conflict of interest.

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