Analysis Of Morphology Of Renal Calyceal Pattern In Renal Donors Using Ct Angiography

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Abstract
Transplants are one of the biggest achievements of modern medicine and can save or greatly enhance the lives of other people. The recovery period after laparoscopic surgery is quicker than open surgery. It is important to know the variations of the renal calyceal pattern prior to the laparoscopic surgery during renal surgeries. The aim is to analyze the calyceal system in kidney donors using 64-Slice Computed Tomography Angiography. The study was conducted in a specialized scan centre located in Chennai after getting appropriate permission and ethical clearance. The study group was drawn from kidney donors who approached the scan centre and had no diseases related to kidney. In this study, a total of 99 healthy kidney donors were included to study the pattern of pelvicalyceal pattern and to classify further into bi-calyceal, tri-calyceal and multi-calyceal. This study found that bi-calyceal pattern is the most common pattern (%) and further this pattern was more in the right side in males and left side in females. The numbers of minor calyces were significantly more in the right multi-calyceal pattern than left multi-calyceal, tri-calyceal and bi-calyceal patterns. The association of occurrence in these pattern was significant in males with a strong association and insignificant in females. A detailed description of intrarenal arterial pattern and its relationship with calyceal pattern will be great significance in renal transplantation and also for other urological procedures.

INTRODUCTION
The kidneys on coronal section have an outer cortex and an inner medulla. Extensions of the cortex centrally as the columns of Bertini separate the medulla into pyramids. The apical portion of the pyramids protruding into the minor calyces is called the papilla. The minor calyces unite with their neighbours to form two or possibly three chambers, the major calyces. The minor calyces, the major calyces, the infundibula, and the renal pelvis are collectively called intrarenal collecting system (Standring,
Variations in the gross anatomy of the renal collecting system are probably as numerous as that of fingerprints of individuals. Each major calyx is formed by the minor calyces and these major calyces drain into the infundibula of the renal pelvis. This calyceal pattern forms the collecting system of the kidney (Dunnick et al., 2008). Variations in the gross structure of the renal collecting system are probably as numerous as there are individuals and thus can be likened to fingerprints (Ningthoujam et al., 2005). The bilateral collecting systems present in any single individual are rarely identical and may be quite different even from one another. The symmetry of the calyceal system in a single individual on both sides is only around 37% (Sampaio and Mandarim-de-Lacerda, 1988). Not only the position and count of different parts of the collecting system vary between individuals, but also the parts can either be absent or numerous (Graves, 1986) made a different type of classification of the pelvocalyceal patterns depending on the shape of the renal pelvis along with prominences of the calyces. Renal collecting system injuries during percutaneous nephrolithotomy (PCN) occur in up to 8% of patients (Mousavi-Bahar et al., 2011). Detailed knowledge of calyceal anatomy is very much essential for all endourological procedures, which is essential for the selection of the best suitable method for kidney stone removal and also this knowledge helps in better interpretation of standard intravenous urography (Hanif et al., 2004). This study was done to know the different patterns of the major calyceal system and its frequency and its corresponding differences in number of minor calyces.

MATERIALS AND METHODS

The present study was carried out after getting approval from the Institutional Human Ethics Committee, Saveetha Medical College and Hospital. The study was conducted in a specialized scan centre located in Chennai from individuals came for investigation for donating kidney after obtaining consent. The renal diseases were ruled out in those individuals after blood investigations and ultrasound. This prospective cross-sectional study conducted on 99 fit kidney donors (male - 54, female - 45) using CT Angiogram. The donors were subjected to CT angiogram and the images were obtained. The CT machine used was light speed VCTXTe, ADW4.5 Version. 64 slice Computed Tomography Angiography. The digital CT angiographic images were collected and the renal pelvis with its branching pattern of the major and minor calyces and their corresponding cap of cortical tissues were analyzed. The major calyceal pattern was studied for the following three types:

1. Bi – Calyceal
2. Tri – Calyceal
3. Multi – Calyceal

Statistical analysis

The association of occurrence of calyceal pattern between male and female was compared analyzed using Chi-square test. Comparison of a number of minor calyces in three types of the major calyceal pattern was analyzed using one way ANOVA and between the sides, student t-test was used. A p-value of less than 0.005 was taken as significant.

RESULTS AND DISCUSSION

In this study, pelvic-calyceal pattern in 198 kidneys (99 donors, both side) were analyzed for the pelvocalyceal pattern (Figure 1) (Table 1). In this study, all the renal pelvis was intra-renal and there was no extra-renal pelvis found.

Bi – Calyceal type

In this study 105, bi-calyceal pattern kidneys were found out of these 105 bi-calyceal kidneys, 56 were on the right side, 49 were on the left side.

Tri-calyceal type

In this study, 58 tri-calyceal pattern kidneys were found. In these 58, the right side was 30; the left side was 28.

Multi-calyceal type

The multi-calyceal pattern was found in 35 kidneys; right side - 13; left side - 22.

Association of occurrence of calyceal pattern

Also, the association of the occurrence of a calyceal pattern among male and female were compared. There was significant association of occurrence in males ($X^2 = 11.968$) with p-value = 0.018 and there

Figure 1: Calyceal pattern with two-division (bi-calyceal), three divisions (tri-calyceal) and multi-calyceal pattern with yellow arrows.
Table 1: Types of calyceal pattern in donors

| S.No. | Gender | Side  | Pattern | Chi-square test |  
|-------|--------|-------|---------|----------------|
|       |        |       | Bi-calyx | Tri-calyx | Multi-calyx |
| 1.    | Male   | Right | 38 (70.4%) | 13 (24%) | 3 (5.5%) | \(\chi^2 = 11.968\) \(p=0.018\) |
|       |        | Left  | 25 (46%)  | 18 (33%) | 11 (20.4%) | |
| 2.    | Female | Right | 18 (40%)  | 17 (37.7%) | 10 (22.2%) | \(\chi^2 = 6.672\) \(p=0.154\) |
|       |        | Left  | 24 (53.3%) | 10 (22.2%) | 11 (24.4%) | |

Values in parenthesis are percentage. There is an association between side and type of calyceal pattern in male. In the female, there is no association between the side and type of calyceal pattern.

Table 2: Comparison of percentage of calyceal pattern in the various study

| Study            | Bi-Calyceal pattern % | Tri-calyceal pattern % | Multi-calyceal pattern % | Unclassified |
|------------------|-----------------------|------------------------|--------------------------|-------------|
| Present study    | 53                    | 29                     | 18                       | -           |
| Anjana et al     | 35                    | 27                     | 23                       | 15          |
| Ningthoujam et al| 21                    | 17                     | 45                       | 17          |
| Gandhi et al     | 59                    | 21                     | 17                       | 03          |

Figure 2: Association of occurrence of a calyceal pattern of right, left and both sides of kidneys among male and female.

was no significant association in females (\(\chi^2 = 6.672\)) (\(p = 0.154\)) (Figure 2).

Comparison of a number of minor calyx in the different calyceal pattern

This study also compared the total number of minor calyx in a different major calyceal pattern on the right side (F= 4.360, p=0.015) and left side (F = 0.162, p=0.851) by one way ANOVA. There was a significant difference in a number of minor calyx in right side multi-calyceal type than left side multi-calyceal type. The number of minor calyces was more on right side (t’ Value = 3.207; value=0.003*). The bi and tri – calyceal type didn’t show significant difference in number of minor calyx in right and left side (Bicalyx t’ Value = 0; ‘p’ Value = 1 ; Tricalyx t’ Value = 0.323; ‘p’ Value = 0.748) (Figure 3).

The significance of knowing the pelvicalyceal system will gain relevance with the advent of newer and effective treatment modalities and investigative procedure to diagnose pathologies involving kidneys. The literature available regarding pelvicalyceal pattern is less; hence this study has done to provide anatomical data of various types of pelvicalyceal pattern in donors.

Figure 3: Comparison of a number of minor calyx in the different calyceal pattern.
Pelvicalyceal pattern

(Sampaio and Mandarim-De-Lacerda, 1988) have studied the pelvicalyceal patterns in the Brazilian population. This study classified the pelvicalyceal system into two groups Group A and B.

Group A- Bi - a calyceal pattern which consists of A1 and A2

Group B- subdivided into B1 and B2

B1- Tri-calyceal pattern

B2- Multi-calyceal pattern.

In the present study, 53% of kidneys were of the bi-calyceal pattern (Group A), 29% of kidneys were of the tri-calyceal pattern (Group B1) and 18% of kidneys were multi-calyceal pattern (Group B2). Comparing these findings with another study done on the human cadaveric kidney (Anjana et al., 2017) they found 35% were bi-calyceal, 27% were tri-calyceal and 23% were multi-calyceal (Table 2). Another study done on intravenous urography showed multi-calyceal pattern was the most common type followed by bi-calyceal pattern, whereas in the present study bi-calyceal pattern was the most common type.

Common types in males and females

The present study provides an insight into the various patterns in live donors of South Indian population. This study also found the most common calyceal pattern among male and female kidneys. In males, the right side bi-calyceal pattern is more common and in females left side bi-calyceal is more common. In tri-calyceal pattern, the left side was more in males and the right side was more common in females. In the multi-calyceal pattern, left side percentage was more in both males and females. In addition to the pattern, this study also found the association of occurrence with this pattern in males and females. The association was significant in males and insignificant in females.

A number of minor calyces

In this study, the number of minor calyces was compared with the major calyceal pattern. There was a significant difference in minor calyces in right side multi-calyceal pattern than the left side. In the right side there was more number of minor calyces in multi-calyceal pattern and this was statistically significant. The remaining pattern (Bi and Tri-calyceal) doesn’t show significant differences in a number of minor calyces. More number of minor calyces can interrupt in endoscopic procedures complicating the surgeries leading to the low success rate.

The embryological basis for different patterns

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. Also, the ureteric bud divides early even before it comes in contact with the metanephric tissues (Pollack and Mcclennan, 2000).

Clinical significance

The knowledge of the pelvicalyceal anatomy in relation to the variation in the number, arrangement of the minor and major calyces, position and presence of intra renal or extrarenal pelvis is clinically important because a huge number of developments have taken place in fields of endourology, percutaneous nephrolithotomy and various urologic procedures (Krishnaveni et al., 2014). These procedures were done using a cannula with the help of imaging techniques keeping in mind the different pelvicalyceal pattern.

CONCLUSIONS

To conclude, this study suggests that apart from detailed clinical history and examination, a thorough and depth anatomical knowledge of calyceal pattern is also important for donor selection. Regional anatomy is evaluated in detail to decide the precise surgical approach, which will avoid donor complication and to ensure good recipient graft function. This study concludes the different calyceal pattern among males and females and its distribution and association. The bi-calyceal pattern is the most common distribution and multicalyceal pattern is the least common pattern. The number of minor calyx is significantly more in the right multicalyceal type. A detailed description of the calyceal pattern will be of great significance in renal transplantation and also for other urological procedures.

Conflict of Interest

The authors declare that they have no conflict of interest for this study.

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REFERENCES

Anjana, T. S. R., Muthian, E., Thiragarajan, S., Shanmugam, S. 2017. Gross morphological study of the renal pelvicalyceal patterns in human cadaveric kidneys. Indian Journal of Urology: IJU, 33(1):36–40.

Dunnick, N. R., Sandler, C. M., Newhouse, J. H., Amis, E. S. 2008. Textbook of Uroradiology. Philadelphia:
Lippincott Williams and Wilkins, 4th edition.

Graves, F. T. 1986. The Anatomy of the pelvis and ureter. Anatomical studies for renal and intrarenal surgery. Bristol: Wright.

Hanif, M. S., Toori, M. H., Sheikh, M. A. 2004. Detailed calyceal anatomy for endourology. Pakistan J. Med. Res, 43(4):184–191.

Krishnaveni, C., Kulkarni, R., Sanikop, M. B., Venkateshu, K. V. 2014. A study of renal calyces by using barium contrast. Int J Anat Res, 2(2):369–374.

Mousavi-Bahar, S. H., Mehrabi, S., Moslemi, M. K. 2011. Percutaneous Nephrolithotomy Complications in 671 Consecutive Patients: A Single-Center Experience. Urology Journal, 8(4):271–276.

Ningthoujam, D. D., Chongtham, R. D., Sinam, S. S. 2005. Pelvi-calyceal system in foetal and adult human kidneys. J Anat Soc India, 54:1–11.

Pollack, H. M., McClennan, B. L. 2000. Clinical Urography, volume 1. Philadelphia: W. B. Saunders Company, 2nd edition.

Sampaio, F. J. B., Mandarim-De-Lacerda, C. A. 1988. Anatomic Classification of the Kidney Collecting System for Endourologic Procedures. Journal of Endourology, 2(3):247–251.

Standring, S. 2008. Gray’s Anatomy. The Anatomical Basis of Clinical Practice. Churchill Livingstone Elsevier Limited, New York, 40th edition.