Detailed calyceal anatomy for endourology
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SUMMARY

Objectives: To understand the detailed calyceal anatomy in our population for endourological procedures.

Material and methods: Fifty patients were selected randomly in the Jinnah Postgraduate Medical Centre Karachi, from January to December 2003 who have been investigated with CT Scan abdomen with contrast. All those patients found to have ectopic or malrotated kidneys were excluded from the study. Similarly patients of renal tumor causing distortion of renal anatomy were also excluded from the study. Anatomy of the kidneys was studied with the help of delayed images of CT scan of abdomen with intravenous contrast delineating the pelvicalyceal system. Degree of rotation of the kidney in longitudinal axis with respect to coronal plane of the body was noted. Angulation of both anterior and posterior calyx with respect to frontal plane of kidney was measured.

Results: Total 80 kidneys were studied including 42 right and 38 left. On average right sided kidneys were rotated posteriorly 35 degree and left sided 22 degree with respect to the coronal plane of the body. Average rotation of the posterior calyces was found 26 degree on the right and 48 degree on the left.

Conclusion: Elevating the operating side 30 degree upward on the right and 20 degree on the left side of a prone patient makes the posterior calyces almost end on which helps in gaining the initial access to collecting system during percutaneous nephrolithotomy and thus decreases the intraoperative complications. Understanding of detailed calyceal system also helps to make 3 dimensional image of the renal collecting system from a standard IVU (Intravenous urography),to exactly localize the stone bearing calyx and for later on flexible nephroscopy.

INTRODUCTION

Collecting system of the kidney comprises of collecting tubules which join together to form collecting ducts. These ducts open at the pyramids in to the main collecting system at the site of minor calyces. The minor calyces, from seven to thirteen in number, are cup shape structures which surround the apices of pyramids forming the fornix, each of which embraces one or more of the renal papillae. The neck of the minor calyces is a narrow structure called infundibulum which unite together to form two to three major calyces. These in turn join to form a funnel shaped sac, the renal pelvis. The renal calyces lie at different angles with respect to frontal (coronal) plane of the kidney. Calyces in the upper and lower pole of the kidney are usually compound and are directed at various angles with in the frontal plane while rest of the calyces are arranged in two distinct rows, one in anterior half and one in posterior half of the kidney. The anterior calyces form an angle of 70 degree with frontal plane and thus are directed straightforward facing the anterior surface of the kidney. The posterior calyces form an angle of approximately 20 degree with frontal plane of the kidney and face a line slightly posterior to lateral convex border of the kidney. In the body kidneys are lying obliquely against the psoas muscles at an angle of approximately 30-45 degrees. Therefore on a standard Intravenous urography (IVU) the anterior row of calyces usually is seen more peripherally and laterally as cup shape structures. Whereas, posterior row of calyces are seen more medially and frontally, as rounded concentration of contrast medium. This is typically called as Brodel type of kidney. In another type called as Hodson type, the anterior calyces are lying at 20 degree while posterior calyces lie at 70 degree with respect to frontal plane of the kidney. Changing the position of the patient from supine to prone position does not change the relative positions of calyces significantly.

Although we have some preliminary data of our population for ultrasonographic assessment of renal size and cortical thickness but the knowledge of detailed calyceal anatomy is also very essential for endourological procedures like, percutaneous nephrostomy which is the most reliable method to predict the future recovery of renal function after the relief of obstructed kidney. Similarly in percutaneous nephrolithotomy, as it has a definite role in management of renal calculi in today’s world. In 1990, only 1-2% of urinary stones were treated by open surgery in well equipped centres. Today, this number is even smaller. Its knowledge is also
essential for endopyelotomy in pelviureteric junction obstruction because if we enter the collecting system from infundibulum in order to gain access to pelviureteric junction, it can lead to very troublesome intraoperative and post operative bleeding. Similarly after vascular injury, chances of arteriovenous fistula and postoperative ischemic necrosis also increase. These can be reduced remarkably by understanding the detailed anatomy of calyceal system of kidney and entering the collecting system through fornax instead of infundibulum.

Knowledge of calyceal anatomy is also helpful for the better understanding and interpretation of standard Intravenous urography (IVU). Although previously infundibulopelvic angle and infundibular length is usually not considered as possible etiological factor for stone formation but it is thoroughly investigated and now considered to have significant impact on stone formation and recurrence. Lower infundibulopelvic angle is the most important factor which can predict the stone free status after extracorporeal shockwave lithotripsy of lower calyceal stone in adults and children. Although, some studies are not conforming it.

MATERIALS AND METHODS

Fifty patients were selected randomly and investigated with the help of abdominal CT Scan with intravenous contrast. A delayed film delineating the pelvicalyceal anatomy was obtained. Study was conducted at Jinnah Postgraduate Medical Centre Karachi, from January to December 2003. Total 42 right and 38 left kidneys were selected for the study. Scans of the kidneys with renal pathological conditions, causing renal or calyceal displacement were excluded. Only those scans in which clear anterior and posterior mid zone calyx could be visualized, were selected. The coronal plane of the kidney was drawn from the most convex part of the lateral renal margin to the mid renal hilum and projected medially to coronal plane of body. Firstly the degree of posterior rotation of coronal plane of kidney to the coronal plane of body was measured. Secondly the angle that the anterior and posterior calyx made with coronal plane of kidney was measured. All this information helped us to detect the direction in which the calyces were pointing in relation to coronal plane of the body, and how far posteriorly the lateral margin of kidney was rotated. Length of the anterior and posterior calyx was also measured. It was also noted whether anterior posterior calyces were situated laterally or would appear superimposed on x-ray in anteroposterior direction. Kidneys in which the anterior calyces projected at a greater angle from coronal plane of kidney than the posterior calyces were called Brodel types and those in which posterior calyces had a greater angle than the anterior calyces were called Hodson types.

RESULTS

On the average anterior calyces were projected forward 36 degree from the frontal plane of the kidney (range 4-96 degree) (Table 1). Anterior calyces of the right kidney (42 cases) were projecting more forward as compared to the left side (38 cases) i.e. 46 degree on right while 25 degree on the left. This is statistically a significant difference. Posterior calyces of the left kidneys were projecting more posteriorly as compared to the right i.e. 26 degree on the right and 47 degree on the left with an overall average of 37 degree (range 0 – 75 degree). Again this is a statistically significant difference (p<0.01). Brodel type of renal model is more observed on the right side as compared to left side whereas Hodson type of renal model is more observed on the left side as compared to right side (Table 1). As there is wide range of angles, therefore not all the kidneys follow the classic picture of either Brodel or Hodson type. However classic picture of Brodel type with greater anterior calyceal angle and shorter length as compared to posterior calyx, was observed more on right side. Similarly classic Hodson type picture with wider posterior calyceal angle and shorter posterior calyx was observed more on left side.

Table 1: Calyceal projection from frontal plane of kidney and major types of kidney

<table>
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<tr>
<th></th>
<th>Right kidneys</th>
<th>Left kidneys</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no kidneys</td>
<td>42</td>
<td>38</td>
<td>80</td>
</tr>
<tr>
<td>Anterior(degree)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av ± standard error</td>
<td>46 ± 5</td>
<td>25 ± 5</td>
<td>36 ± 5</td>
</tr>
<tr>
<td>(Range)</td>
<td>(8-96)</td>
<td>(4-65)</td>
<td>(4-96)</td>
</tr>
<tr>
<td>Posterior(degree)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Av ± standard error</td>
<td>26 ± 5</td>
<td>48 ± 5</td>
<td>37 ± 5</td>
</tr>
<tr>
<td>(Range)</td>
<td>(0-55)</td>
<td>(15-75)</td>
<td>(0-75)</td>
</tr>
<tr>
<td>Brodel No (%)</td>
<td>28 (67)**</td>
<td>12 (32)**</td>
<td>40</td>
</tr>
<tr>
<td>Hodson No (%)</td>
<td>12 (29)</td>
<td>24 (63)</td>
<td>36</td>
</tr>
</tbody>
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* p <0.01 compared to the right kidney  
In two cases in either group anterior and posterior calyces were projecting equally.

Another variable which was observed in the study was posterior rotation of lateral renal margin (Table2). Degree of posterior rotation of frontal aspect of the kidney from the coronal plane of the body was measured. On the average it was found to be 29±2 degree (ranging from 8-50 degree). Right kidney was rotated more posterior as compared to left one i.e. 35 degree on the right and 22 degree on the left. Considering the angles of the calyces along with their length it was noted that on
the average anterior calyx was projected more lateral in 54 (67.5%) kidneys and in 21 (26%) kidneys the anterior and posterior calyces were projecting almost equally from the lateral renal margin. In only 5 kidneys (6%) the posterior calyx was more laterally projected than anterior.

Table 2: Posterior rotation of frontal plane of kidney with respect to coronal plane of body.

<table>
<thead>
<tr>
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</tr>
<tr>
<td>Av degree ± standard error</td>
<td>35±2</td>
<td>22±2*</td>
<td>29±2</td>
</tr>
<tr>
<td>Range (degree)</td>
<td>12-50</td>
<td>8-45</td>
<td>8-50</td>
</tr>
</tbody>
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*p<0.01 compared to right kidney

Discussion

IVU is considered to be the basic investigation in planning the treatment of renal calculi endourologically. When we examine the standard IVU (antero posterior view) the compound polar calyces, the laterally positioned side on appearance of cup shaped anterior calyces and medially placed end on rounded appearance of posterior calyces can be appreciated. As the kidneys are placed along the posterior abdominal wall in oblique fashion their hilum is rotated anteriorly and medially while lateral renal margin is rotated posterolaterally. So this swings the anterior calyces more laterally and posterior calyces medially.

In our study we have seen that in 67.5% cases (82% on left and 52% on the right) the anterior calyces of the kidney will be seen more laterally in a standard IVU film and in only 6% cases the reverse is true. Where as in 26% cases (36% right and 16% left) it will be impossible to differentiate between the anterior and posterior calyx, on an IVU. When classical Brodel type of kidney exist with the longer posterior calyx, slight posterior rotation of lateral renal margin makes the calyces superimposed and thus makes it difficult to differentiate the anterior calyx from the posterior calyx on IVU. Three dimensional mental image of calyceal anatomy and localization of stone in the particular calyx is required to perform percutaneous nephrolithotomy in renal calyceal calculi. Its importance also increases when flexible nephroscope is used. For the safe percutaneous procedure the patient must be positioned properly on the fluorooscope table. Patient is laid in prone position which does not alter the relative position of the calyces with respect to coronal plane of the body. Usually the posterior calyx is entered in the lower or middle pole of the kidney at the site of the fornix of the calyx slightly posterior to lateral renal margin in the avascular plane to decrease the intraoperative haemorrhage. When operating on the right kidney 30 degree elevation of operative side makes the posterior calyx almost end on in fluoroscope in most of the cases.

(\text{Post. rotation of patient} + \text{post. rotation of kidney} + \text{post. Calyceal angle} = 30+35+26=90)

This makes relatively easy target for puncture and prevents overshooting of the puncture needle. Similarly on the left side elevating the patient 20 degree upward on the left side in the prone position will make the posterior calyx of left kidney end on in most of the cases.

\text{Post. Rotation of patient} + \text{post. Rotation of kidney} + \text{post. Calyceal angle} = 20+22+48=90

We must also keep in mind that these figures are not absolute as there is wide range of variation in renal calyceal angulation (0-55° on the right and 15-75° on the left) so some time degree of elevation has to be individualized according to that particular case. In general left sided calyces are angulated more posteriorly as compared to right so elevation required on left side is less as compared to right side. These results are similar to that of Keith W. Kaye and Reinke who has recommended 30 and 10 degree elevation on the right and left side respectively.

These principals can also be helpful in performing percutaneous nephrostomy in mildly dilated system. This study is also helpful in performing retrograde percutaneous nephrostomy. In this method a wire is passed up in the ureter into the kidney endoscopically and then out through the exact calyx that would give best access for removing the stone or performing the specified endourological procedure. To perform these procedures surgeon must be able to interpret the IVU correctly. As most of the time posterior calyx is used, the retrograde tract pass posterolaterally, as indicated by Hunter and associate little damage would occur presumably as wire could exit through the skin behind the mid axillary line. These retrograde nephrostomy punctures are not usually performed nowadays due to potential risk of injury to intraperitoneal organs when anterior calyces with minimally rotated kidney is selected which is 8 degree in our series.

Conclusion

Understanding of detailed calyceal anatomy is necessary to have three dimensional orientation of renal collecting system from a standard IVU. Exact localization of stone and orientation of the calyx is required while doing percutaneous nephrolithotomy in calyceal stones. 3-dimension orientation and knowledge of calyceal
angulations, also helps to avoid unnecessary bleeding occurs during calyceal access, in percutaneous endourological procedures. Elevating the operating side 30 and 20 degree upward on the right and left side respectively in prone patient will help to gain access of posterior calyces through avascular plane and thus minimize the risk of severe intraoperative bleeding and procedure failure.

REFERENCES