INTRODUCTION

The existence of kidney stones was first recorded thousands of years ago, and lithotomy for the removal of stones is one of the earliest known surgical procedures. In 1901, a stone was discovered in the pelvis of an ancient Egyptian mummy and was dated to 4,800 BC ***(Eknoyan, 2008).***

Until the 1980s urinary stones were a major health problem with a significant proportion of patients requiring extensive surgical procedures. One study showed that about 20% of patients with recurrent stone disease who underwent surgery for obstruction and infection went on to develop mild renal insufficiency ***(Borofsky and Shah, 2013)***.

A variety of minimally invasive options exist for the treatment of patients with upper-tract urolithiasis and as technology advances, so evolve the options. Open stone surgery has been rendered obsolete except in some situations like Stag Horne stones, being surpassed by ante grade and retrograde endoscopic techniques, as well as extracorporeal shockwave lithotripsy (SWL). The challenge facing urologists is the need to balance treatment effectiveness against morbidity, based on each clinical scenario ***(Antonelli and Pearle, 2013).***

The management of urinary calculi has undergone dramatic changes since the early 1980s with the introduction of extracorporeal shock-wave lithotripsy (ESWL) using the

Dornier HM_3 device. Advances of flexible, semi rigid and rigid ureteroscopes combined with the development of effective intra corporeal lithotriptors as well as further advancement in urologic laparoscopic surgery has almost eliminated open stone surgery in favor of minimally invasive stone removal techniques and have greatly improved the urologist's ability to treat upper tract stones ***(Bader et al., 2010).***

The gold standard for removal of renal stones more than 2 cm in diameter is percutaneous nephrolithotripsy (PNL). Retrograde intrarenallithotrepsy (RIRl) has become more and more fashionable because of its high safety and repeatability, especially in smaller stones. Many retrospective studies have proved its efficacy and safety in larger calculi ***(Bryniarski et al., 2012).***

PNL currently remains the gold-standard approach for difficult-to-treat renal stones (large and/or complex calculi, hard or lower pole calculi, stones associated with abnormal renal anatomy, and persisting after failure of other treatments) and/or complex patients (of all ages and body habitus). PNL safety and efficacy reflect the consistent improvements in technology and surgical skills, and likely explain the increasing use of this technique over the past two decades ***(Resorlu et al., 2010).***

While PNL has an excellent success rate in clearing stone burden, it is invasive, The morbidity associated with PNL is acceptable for the majority of patients However, the low but significant rate of major complications include acute or partial renal loss, chronic renal failure, prolonged urine leakage, septicaemia bleeding requiring transfusion and Injury to adjacent organs (such as spleen, liver, lung, and colon) required prolonged inpatient hospital stay ***(Bader et al., 2010).***

Retrograde intra renal surgery (RIRS) is a procedure that has evolved since the advent of flexible laser fibers. Since its introduction in 1990, it has been used for small renal stones and after extracorporeal shockwave lithotripsy (SWL) failure. With flexible ureteroscopes, urologists are now able to access even the lower calices of the kidney. Unfortunately, these procedures have quite long learning curves and are burdened with high rates of fiber breakage. This may increase the complication rate and costs of the procedure. Therefore, RIRS with a flexible ureteroscope is used for smaller stones or, subsequently, after RIRS with a semirigid ureteroscope to disintegrate stone debris in the lower calix ***(Bryniarski et al., 2012).***

Minor complication rates post retrograde holmium laser uretroscopy range from 0% to 13% and consist primarily of pain or urinary tract infection. Significant complications, including ureteral stricture, have been reported to occur in 1.5% of patients undergoing ureteroscopy. These minor complications allow for the management of large stone burdens that were previously only manageable by PNL ***(Bader et al., 2010).***

Aim of the Work

To illustrate the advantages and disadvantages of retrograde intra renal holmium laser uretroscopy (RIRL) versus percutaneous nephrolithotomy (PNL) in management of renal pelvic stone.

ANATOMY

Renal anatomy

Kidney Position and External Relationships

The kidneys lie in the retro peritoneum on top of the quadrates lumborum and psoas muscles. Each kidney has a thin walled fibrous capsule that is intimately adherent to the parenchyma which in turn is surrounded by perirenal fat. The perirenal fat is contained by Gerota's fascia, which in turn is surrounded by another layer of fat (i.e., the pararenal fat). Posteriorly the superior pole of each kidney rests against the diaphragm and the tips of the 11th and 12th ribs. Deep to this the underlying pleura attaches to the 11th rib, which must be considered when a superior pole percutaneous approach is planned especially on the left where the kidney lies higher in the retroperitoneum ***(Anderson and Cadeddu, 2012).***

The adrenal glands rest on top of the kidneys medially against the cava on the right and aorta on the left. The anterior surface of the right kidney is associated with the liver superiorly, the curve of the duodenum over the midportion and the ascending colon inferior and medially. On the right side, the colon often covers the lower half of the kidney medially ***(Eichel and Clayman, 2007).***

The anterior surface of the upper pole of the left kidney is covered by the spleen superiorly and just the tail of the pancreas medially as well as by the splenic flexure of the colon ***(Anderson and Cadeddu, 2012).***

The anteromedial surface of the entire left kidney is covered by the descending colon. A retrorenal colon can be seen on either side in 1–10% of percutaneous cases depending on patient positioning; it is more common when the patient is in the prone position. However, this condition is usually limited to patients with a markedly redundant colon or patients with a horseshoe kidney). Usually the retrorenal colon covers only the lateral most portion or upper pole of the kidney ***(Sampaio, 1996).***

For anatomic purposes the kidney can be divided into anterior and posterior segments. The plane of division for these segments rests 30–50% posterior to the frontal plane of division for the body as a whole owing to the rotation of the renal axis anteriorly by the psoas major muscle. The psoas muscle also defines the axis of the kidneys in the longitudinal plane so that the upper pole is medial and posterior whereas the lower pole is more lateral and anterior. As such, the distance from skin to collecting system is shortest at the upper pole and greatest at the lower pole of the kidney ***(Sampaio, 2000).***

Internal Architecture of the Kidney and Collecting System

Pelvicalyceal System

Endourologic Implications:

Basic Intrarenal Anatomy The renal parenchyma consists basically of two kinds of tissue, the cortical tissue and the medullary tissue. On a longitudinal section, the cortex forms the external layer of renal parenchyma. The renal medulla is formed by several inverted cones, surrounded by a layer of cortical tissue on all sides (except at the apexes). As in longitudinal sections, a cone assumes the shape of a pyramid and the established expression for the medullar tissue is renal pyramid; the apex of a pyramid is the renal papilla. The layers of cortical tissue between adjacent pyramids are named renal columns (cortical columns of Bertin).

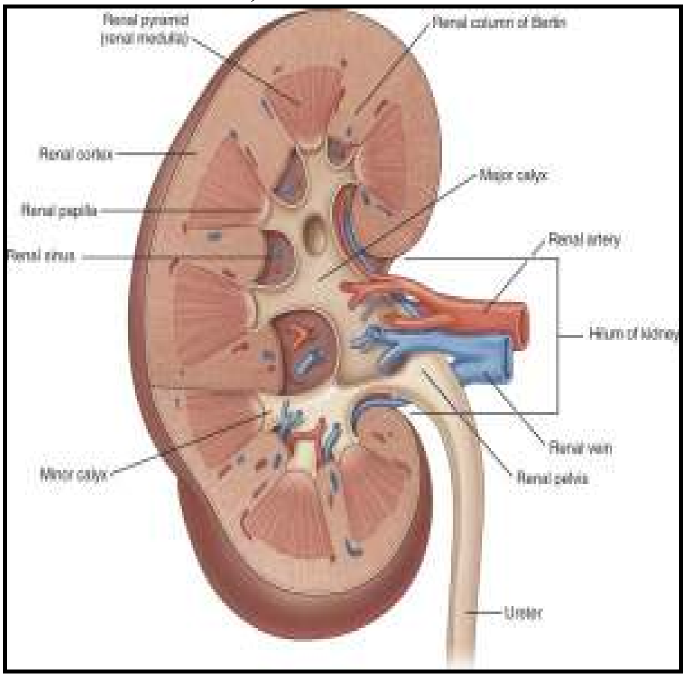

Fig. (1): Internal structure of the kidney quoted from ***(Drake et al., 2005).***

The cortical tissue comprises the glomeruli with proximal and distal convoluted tubules. The renal pyramids comprise the loops of Henle and collecting ducts; these ducts join to form the papillary ducts (about 20) which open at the papillary surface (area cribrosa papillae renalis) draining urine into the collecting system (into the fornix of a minor calyx)

A minor calyx is defined as the calyx that is in immediate opposition to a papilla. The renal minor calices drain the renal papillae and range in number from 5 to14 (mean, 8); although the number of minor calices is widely varied, it was found that; 70% of the kidneys presenting 7 to 9 minor calices. A minor calyx may be single (drains one papilla) or compound (drains two or three papillae). The polar calices often are compound, markedly in the superior pole. The minor calices may drain straight into an infundibulum or join to form major calices, which subsequently will drain into an infundibulum. Finally, the infundibula, which are considered the primary divisions of the pelvicalyceal system, drain into the renal pelvis ***(Drake et al., 2005).***

Calyceal arrangement

For the endourologist, a thorough understanding of the calyceal arrangement is essential. The upper and lower pole calyces are usually compound and project in polar direction. The remaining calyces are arranged into distinct rows: anterior and posterior, the anterior calyces usually form an angle of 70˚

with the frontal plane of the kidney, whereas the posterior calyces usually form an angle of 20˚ with the frontal plane, and therefore face slightly posterior to the lateral convex border of the kidney. On occasion, the converse applies (anterior calyces 20˚ and posterior calyces 70˚) ***(Drake et al., 2005).***

The traditional teaching regarding the correlation between the actual anatomy of the pelvicalyceal system and the appearance of the collecting system on intravenous urography (IVU) is that on a standard anteroposterior view the anterior calices appear to be seen in cross section laterally, and the posterior calices appear to be more medial and are seen from a cup-like end on point of view ***(Kim and Clayman, 2006).***

Crossed Calyces: In 17.2% of the cases, the kidney's midzone (hilar) was drained by crossed calyces, one draining into the superior calyceal group and the other draining into the inferior calyceal group simultaneously. On the pyelograms, the crossed calyces (laterally) and the renal pelvis (medially) outlined a radiolucent region that termed the inter-pelvicalyceal region.When the crossed calyces were in the mid kidney, the calyx that drained into the inferior calyceal group was in ventral position in 87.5% ***(Eichel and Clayman, 2007).***

In the case of IVU or retrograde pyelography this should include lateral and oblique views. Similarly, at the time of planned PNL, anteroposterior as well as oblique views need to be obtained such that the targeted calyx is of a posterior nature. Similar information can also be obtained from 3-D reconstruction of CT images ***(Kim and Clayman, 2006).***

Assessment of the Lower Pole Infundibulopelvic Angle, Infundibular Length, Infundibular Width, and Calyceal Pelvic Height

It is widely accepted among endourologists that lower pole calculi have a poor clearance rate compared to stones in other locations following shockwave lithotripsy. The dependent position of the lower pole is thought to play a major role. Other important anatomical relationships to understand with regard to this phenomenon are the lower pole infundibulopelvic angle (LIP angle), infundibular length (IL), infundibular width (IW) and calyceal pelvic height (CPH). Several studies exist in the literature that either support or refute the importance of these parameters with regard to stone clearance rates and treatment success rates for lower pole stones. When reviewing studies that use the LIP angle as a potential indicator of the odds of treatment success, it is important to remember that the angle can be measured several ways ***(Eichel and Clayman, 2007).***

The measurement is calculated using the angle between the central axis of the lower pole infundibulum and one of the following: the ureteropelvic axis, the vertical ureteral axis, or the renal pelvic axis ***(Madbouly, 2001),*** The IL is calculated as the distance from the most distal point at the bottom of the calyx containing the stone to the midpoint of the lower lip of the renal pelvis ***(Elbahnasy et al., 1998).***

Another similar measurement used to predict odds of stone clearance is the CPH. This is defined as the distance between the lower lips of the renal pelvis the lowermost point of the stone containing calyx ***(Poulakis et al., 2003).***

The IW is measured at the narrowest point along the lower pole infundibular axis. Several studies support the theory that lower pole infundibulopelvic anatomy affects stone clearance rates. ***Sampaio and Aragao*** studied endocasts from the collecting systems of 146 cadaveric kidneys. He found three factors that may play a role in lower pole stone clearance: the infundibulopelvic angle (clearance of 74% when the angle is >90% and 26% when the angle is <90%), the infundibular diameter (60% clearance when it is >4 mm and 40% clearance when it is <4 mm), and the inferior pole calyceal distribution (57% clearance when the calyces were multiple and simple vs

43% when the calyces were single and of a compound nature) ***(Sampaio and Aragao, 1992).***

Patients with lower pole stones 17 mm or less who have favorable anatomy (LIP angle >70%, IL <3 cm, and IW >5 mm) are excellent candidates for SWL whereas patients with less favorable anatomy (LIP angle <40%, IL >3 cm, and IW <5mm) would be better served by ureteroscopy or PNL. In further support of these findings ***(Sampaio et al., 1997).***

Keeley et al. retrospectively analyzed the records of 116 patients with lower pole stones between 11 and 20 mm with regard to LIP angle and also found a superior stone free rate among patients with a more obtuse angle ***(Keeley et al., 1999).***

Intra renal Vascular Anatomy

Intrarenal Arteries:

Although wide variation exists, the renal arteries in general originate from the lateral margin of the aorta just below the level of the superior mesenteric artery. They course posterior to the renal vein and branch on the appropriate side of the renal pelvis into an anterior and posterior division ***(Eichel and Clayman, 2007).***

Generally, the main renal artery divides into an anterior and a posterior branch after giving off the inferior suprarenal artery. Whereas the posterior branch (retro pelvic artery) proceeds as the posterior segmental artery to supply the homonymous segment without further significant branching, the anterior branch of the renal artery provides three or four segmental arteries. The segmental arteries divide before entering the renal parenchyma into inter lobar arteries (infundibular arteries), which progress adjacent to the calyceal infundibula and the minor calices, entering the renal columns between the renal pyramids. As the interlobar arteries progress, near the base of the pyramids, they give origin (usually by dichotomous division) to the arcuate arteries. The arcuate arteries give off the interlobular arteries, which run to the periphery giving off the afferent arterioles of the glomeruli ***(Drake et al., 2007).***

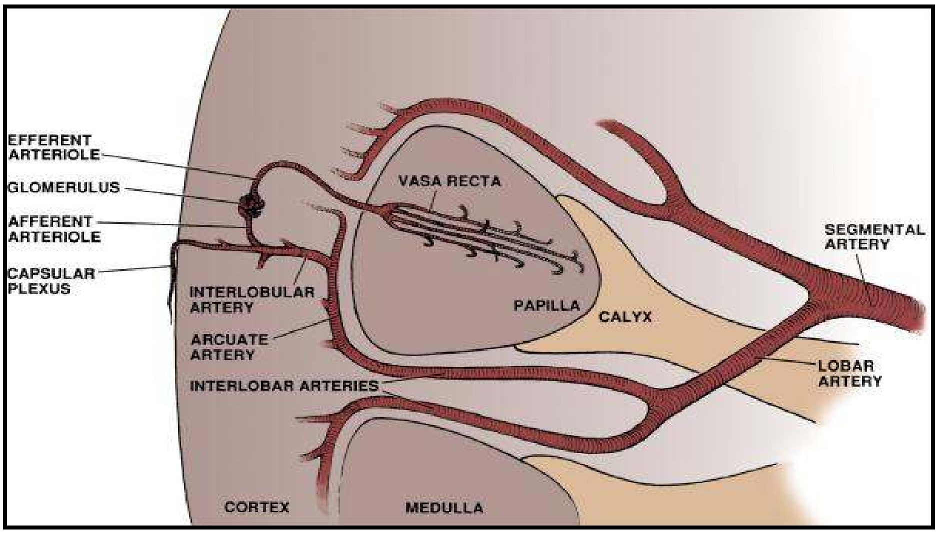

Fig. (2): Intrarenal arterial anatomy **quoted from *(Drake et al., 2007).***

The kidney is supplied by the anterior and posterior branches of the main renal artery. The anterior branch supplies both the anterior half of the kidney and the polar regions via four segmental branches. The posterior branch of the renal artery supplies the posterior aspect of the kidney (represented by the shaded region). The junction between the anterior and posterior divisions of the renal artery results in a relatively avascular plane **Brodel's line**. There are no marks on the surface to demonstrate this area, however it usually located 1-2 cm posterior to the lateral margin of the kidney ***(Hopper et al., 1990).***

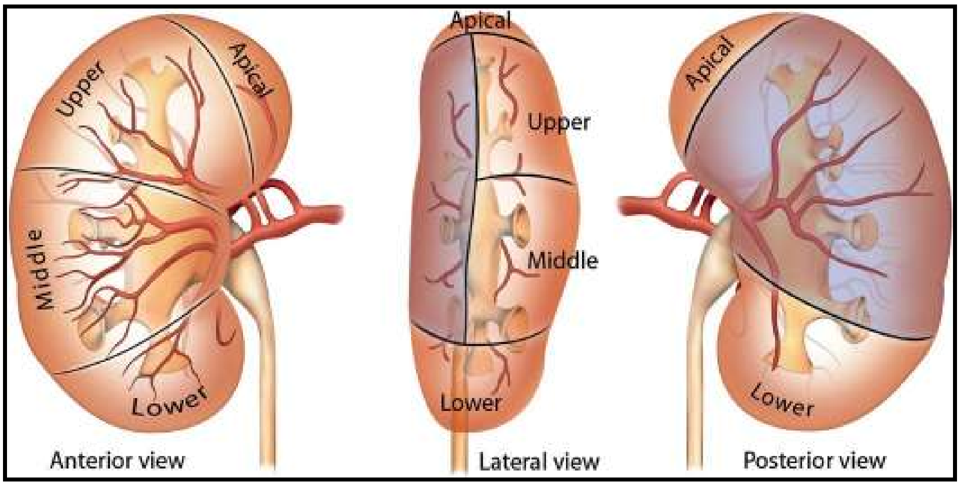

Fig. (3): Showed segmental blood supply of the kidney and Brodel's line. ***Quoted from (Hopper et al., 1990).***

From this, it can be seen that, the safest place to percutaneously access the collecting system is directly into the calyceal fornix because this will avoid the interlobar (infundibular) arteries adjacent to the calyceal infundibula and the arcuate arteries that skirt the renal pyramid, usually the lowermost calyx. An approach through infundibulum, especially the superior infundibulum may be dangerous because of the large vessels and major branches that cross the infundibular surfaces. The superior pole infundibulum for example, may almost be encircled by the upper segmental artery anteriorly and the posterior segmental artery posteriorly ***(Eichel and Clayman, 2007).***

It can be also seen that the safest place to puncture the kidney is just posterior to the line of maximal convex curvature (Brodel's line) ***(Drake et al., 2007).***

Sampaio et al. performed three-dimensional endo casts of renal collecting systems, arteries, and veins in fresh cadavers.They also studied the extent of vascular injuries sustained from percutaneous punctures of the renal collecting system at various locations and they discovered that there is a high likelihood of a significant vascular injury if the collecting system is punctured through an infundibulum or if the renal pelvis is accessed directly because the larger vessels surround these structures. Significant vascular injuries were discovered in 67%, 23%, and 13% of upper pole, middle, and lower pole infundibular punctures respectively ***(Sampaio et al., 1992).***

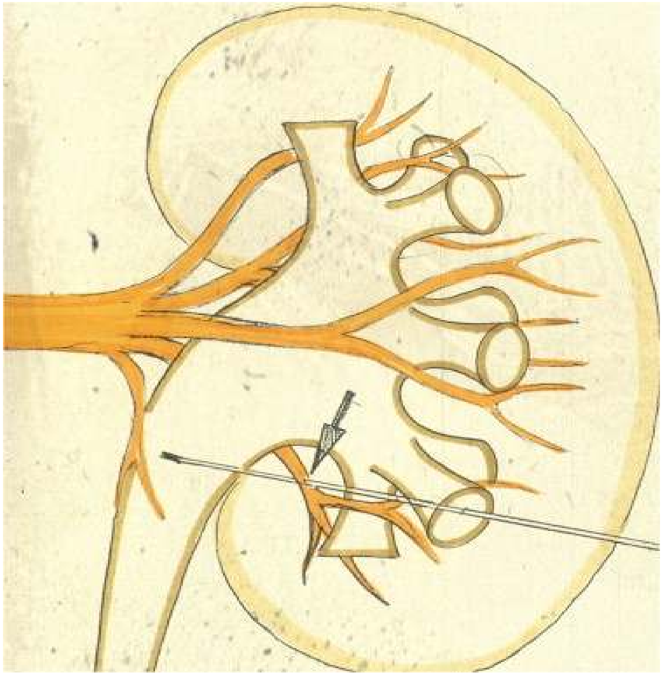

Fig. (4): Renal vascular anatomy. Puncture of renal pelvis or through caliceal infundibulum leads to an increased risk of vascular injury. ***Quoted from (Eichel and Clayman, 2007).***