# INTRODUCTION

Although stone disease is one of the most common diseases of modern society, it has been described since antiquity ***(Pearle et al., 2005).***

The lifetime prevalence of kidney stone disease is estimated at 1% to 15%, with the probability of having a stone varying according to age, gender, race, and geographic location ***(Stamatelou et al., 2003).***

Staghorn calculi are those stones that fill the major part of the renal collecting system. Typically, they occupy the renal pelvis and branch into most of the calyces, mimicking the horns of a deer or stag. Staghorn stones may be composed of struvite, cystine, calcium oxalate monohydrate or uric acid ***(Gettman and Segura, 1999).***

The term "partial staghorn" calculus designates a branched stone that occupies part but not all of the collecting system while "complete staghorn" calculus refers to a stone that occupies virtually the entire collecting system ***(Preminger et al., 2005).***

Patients suffering from staghorn calculi remain a challenging problem for the practicing urologist. It is now generally accepted that, if left untreated, a staghorn calculus is associated with progressive deterioration of renal function, recurrent urinary tract infection and sepsis ***(Wein et al., 2012).***

The rate of malignancy in patients with staghorn stone was 0.9% and a positive biopsy rate of 4.5% over suspicious mucosa close to the stone during PNL ***(Chen et al., 2009)***.

The ideal management of patients with staghorn calculi is complete removal of the entire stone burden to eradicate any causative organisms which can lead to eventual stone regrowth. Anatomic abnormalities that contribute to stasis within the urinary tract should be addressed and any metabolic abnormalities must be appropriately treated ***(Wein et al., 2012).***

The four accepted active treatment modalities are Percutaneous nephrolithotomy (PNL) monotherapy, combinations of PNL and shock-wave lithotripsy (SWL), SWL monotherapy and Open surgery (anatrophic nephrolithotomy or nephrectomy) ***(Preminger et al., 2005).***

A newly diagnosed patient should be actively treated. The patient must be informed about the relative benefits and risks associated with the active treatment modalities ***(Preminger et al., 2005).***

Nonsurgical treatment with antibiotics and urease inhibitors is not a viable alternative except in patients otherwise too ill to tolerate stone removal ***(Preminger et al., 2005).***

As a guideline, PNL is the treatment of choice except for patients with extremely large and/or complex stones. If combination therapy is undertaken, PNL should be the last procedure for most patients as it allows for better assessment of stone- free status and a greater chance of achieving this state ***(Preminger et al., 2005).***

SWL monotherapy has a limited role in the management of this type of stone burden and should be reserved for use in pediatric patients with normal collecting-system anatomy. Adequate drainage of the treated renal unit with either an internal ureteral stent or percutaneous nephrostomy tube should be established before treatment ***(Preminger et al., 2005).***

SWL monotherapy for staghorn calculi is associated with poor stone-free rates and require a greater number of secondary procedures. Postoperative complications are more common and include steinstrasse, ureteral obstruction, renal colic, perinephric hematoma, pyelonephritis and sepsis ***(Matlaga and Lingeman, 2012).***

Stone-free rates for PNL-based therapy and open surgery are similar. PNL-based therapy has advantages of reduced convalescence, shorter hospitalizations, reduced narcotic requirements and patients are not subjected to incisions, hernia or eventration of flank musculature ***(Preminger et al., 2005).***

However, PNL may be associated with some complications as colon injury, hydrothorax, pneumothorax, prolonged leak, sepsis, ureteral stone, vascular injury and acute loss of kidney ***(Preminger et al., 2005).***

Total complication rates of PNL, including insignificant bleeding and fever, are reported to be as high as 83%. The rates of significant bleeding requiring transfusion and of sepsis are 5% to 18% and 1% to 4.7%, respectively. Regarding pleural injuries, complication rates have been reported to range from 2.3% to 23%, depending on the definition of injury ***(Taneja, 2010).***

With increasing stone size and complexity, PCNL can require a longer operative time, a larger volume of irrigant fluid, and multiple tracts to achieve better stone clearance. Therefore, fear exists of greater bleeding and complication rates. However, it has been shown that an aggressive approach to staghorn calculi using multiple tracts PCNL is safe and effective. The supracostal approach can be used more often to gain optimal access to staghorn stones ***(Singla et al., 2008).***

Complication rate of a supracostal approach is threefold greater than that of a subcostal approach with reported complication rates of 23% to 100% and 1% to 13% for supra $11^{th}$ and supra $12^{th}$ rib respectively. The risk of pulmonary injury is twofold greater on the right side than on the left side ***(Loughlin, 2007).***

The effects on renal function from PNL are believed to be minimal. Reports of imaging studies before and after PNL have demonstrated small parenchymal scars at the tract site ***(Taneja, 2010).***

Teichman and colleagues reported that 25% of patients with staghorn calculi treated with PNL had a decrease in renal function. These investigators cited solitary kidney, recurrent calculi, hypertension, complete staghorn calculus, urinary diversion, and neurogenic bladders as further risk factors for functional deterioration in this group ***(Teichman et al., 1995).***

Chatham and colleagues evaluated patients before and after PNL with technetium-99m mercaptoacetyltriglycine nuclear renography. These investigators demonstrated stable or improved renal function in 84% of patients and deterioration of function in 16% ***(Chatham et al., 2002).***

Acute renal loss is very uncommon following PNL. It is usually secondary to uncontrollable hemorrhage. The incidence has been reported to be between 0.1% - 0.3% and up to 1.6% in the long-term ***(Taneja, 2010).***

Open surgery may be considered in patients with extremely large staghorn calculi not expected to be removed by a reasonable number of less invasive procedures ***(Preminger et al., 2005).***

Patients with an associated anatomic abnormality requiring open operative intervention, such as UPJ obstruction and infundibular stenosis, may be candidates for an open surgical approach. Some patients requiring open surgery unrelated to their urologic problem may also benefit from a simultaneously performed open procedure ***(Wein et al., 2012).***

There are no strict guidelines that define which patient should undergo an open surgical procedure for stone removal. Some indications, such as a stone burden too large for PNL, clearly rely on the surgeon’s judgment and experience and the availability of equipment ***(Matlaga and Lingeman, 2012).***

Patients harboring such large or complex calculi could be effectively treated with extended pyelolithotomy combined with multiple radial nephrotomies ***(Wickham et al., 1974).***

Boyce and Elkins (1974) established anatrophic nephrolithotomy, a technique of incising the renal parenchyma along the avascular plane (Brodel, 1900) between the anterior and posterior vascular distributions. This procedure permits a relatively bloodless operation that encompasses stone removal, reconstruction of the calyceal system, and closure of the renal capsule with preservation of renal function ***(Matlaga and Lingeman, 2012).***

Open stone surgery may have some pulmonary complications as pulmonary dysfunction resulting from the flank position or pneumothorax ***(Taneja, 2010).***

Significant postoperative renal hemorrhage occurs in <10% of open renal surgical procedures ***(Taneja, 2010).***

Prolonged urinary leakage represents another complication associated with renal surgery. Distal ureteral obstruction, UTI, and the presence of foreign bodies are the main causes. Urinoma formation is a rare complication resulting from premature removal of operative drains. In the presence of UTI, sepsis can result. Placement of a ureteral stent is helpful in managing this problem and percutaneous or formal drainage may be required ***(Taneja, 2010).***

Trauma to the renal parenchyma can result in diminished renal function postoperatively. Boyce and Elkins noted that of 100 patients undergoing nephrolithotomy, only 2 showed a decrease in renal function postoperatively and 1 of the patients required a nephrectomy ***(Taneja, 2010).***

Laparoscopic anatrophic nephrolithotomy has been reported in animal models and small case series ***(Simforoosh et al., 2008).***

Initial reports are encouraging, but, to date, renal functional outcomes in humans have not been evaluated with nuclear renal scans. Further studies are required to assess the feasibility of this procedure ***(Matlaga and Lingeman, 2012).***

Nephrectomy should be considered when the involved kidney has negligible function with normal contralateral kidney ***(Preminger et al., 2005).***

# Aim of the Work

The purpose of this study is to outline the current role of open surgery versus percutaneous nephrolithotomy in management of renal staghorn calculi.

# SURGICAL ANATOMY OF THE KIDNEY

The kidneys are paired organs lie retroperitoneal on the posterior abdominal wall. They extend from the level of the 11th or 12th thoracic vertebra superiorly to the 3rd lumbar vertebra inferiorly with the right slightly lower due to the presence of the liver. The lateral surface of each kidney is convex; the medial surface is concave and has a vertical cleft called the renal hilum, which contains the renal vessels, nerves and the renal pelvis. The relative positions of the main hilar structures are the renal vein (anterior), the renal artery (intermediate) and the pelvis of the kidney (posterior). On the superior part of each kidney lies an adrenal gland ***(Marieb et al., 2012)***.

## Position of the Kidneys

The kidneys lie retroperitoneal against the psoas major muscles so, their longitudinal axis parallels the oblique course of the psoas (Fig. 1).

Therefore, the upper pole is medial and posterior whereas the lower pole is more lateral and anterior. So, the distance from skin to collecting system is shortest at the upper pole and greatest at the lower pole of the kidney ***(Sampaio, 2007).***

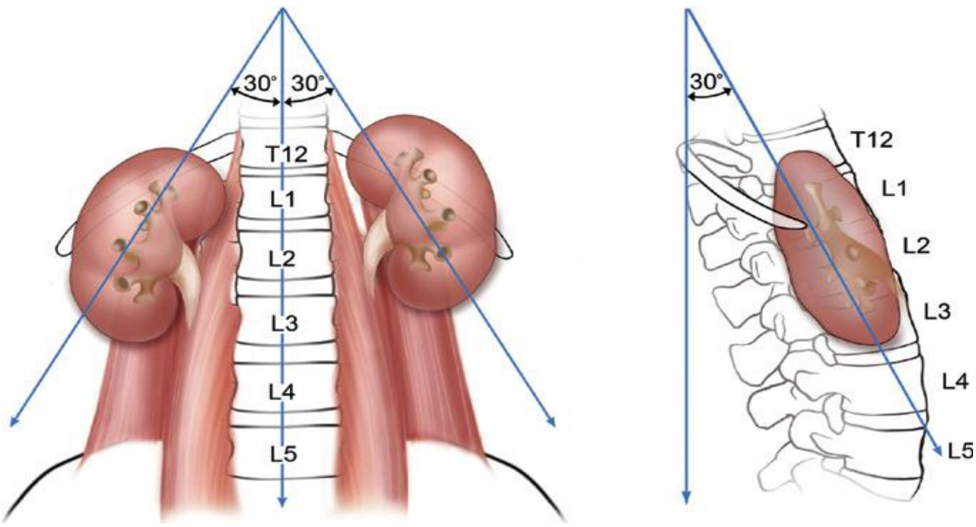


**Figure (1):** Location of kidneys in relation to the skeleton. The superior poles more medial and posterior than the inferior poles ***(Wolf, 2012).***

As the hilar region is rotated anteriorly on the psoas muscle, the lateral borders of both kidneys are posteriorly positioned. It means that the kidneys are angled 30 to 50° behind the frontal (coronal) plane. The anterior surface of the kidney actually faces anterolaterally. Likewise the posterior surface of the kidneys in reality faces posteromedially (**Fig. 2**).

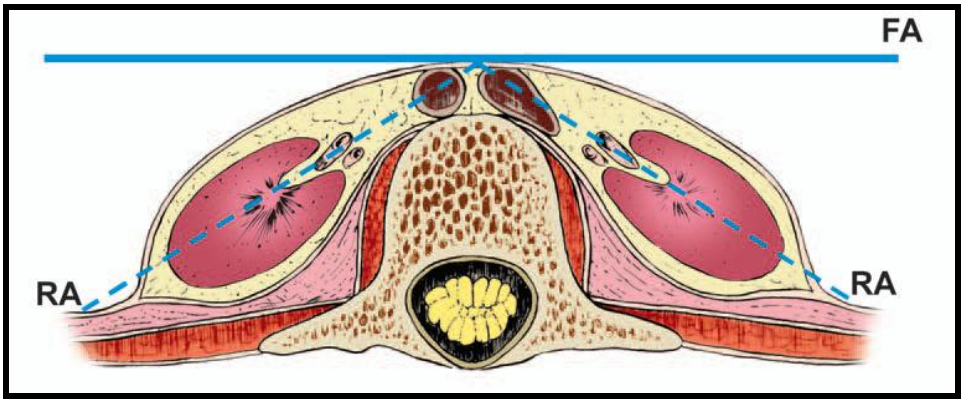


**Figure (2):** Superior view of a transverse section of the kidneys at the level of the 2nd lumbar vertebra shows that the renal axis (*RA)* is angled 30 to 50° behind the frontal (coronal) axis (*FA)* of the body ***(Sampaio, 2007)***.

## Perirenal Coverings:

The kidney surface is enclosed in a covering of fibrous tissue called the renal capsule. Each kidney within its capsule is surrounded by a mass of adipose tissue called the perirenal fat. The perirenal fat is enclosed by the renal fascia (Gerota's fascia). The renal fascia is enclosed anteriorly and posteriorly by another layer of adipose tissue, called the pararenal fat ***(Marieb et al., 2012)***.

The renal fascia comprises a posterior layer (a well-defined and strong structure) and an anterior layer, which is a more delicate structure that tends to adhere to the peritoneum. The anterior and posterior layers of the renal fascia (Gerota's fascia) subdivide the retroperitoneal space in three potential compartments: (1) the posterior pararenal space, which contains only fat; (2) the intermediate perirenal space, which contains the suprarenal glands, kidneys and proximal ureter, together with the perirenal fat; (3) the anterior pararenal space which extends across the midline from one side of the abdomen to the other. This space contains the ascending and descending colon, the duodenal loop and the pancreas ***(Sampaio, 2000)***.

Inferiorly, the layers of the renal fascia end weakly fusing around the ureter. Superiorly, the two layers of the renal fascia fuse above the suprarenal gland and end fusing with the infra-diaphragmatic fascia. Laterally, the two layers of the renal fascia fuse behind the ascending and descending colons.

Medially, the posterior fascial layer is fused with the fascia of the spine muscles. The anterior fascial layer merges into the connective tissue of the great vessels (Aorta and IVC) ***(Sampaio, 2000).***

## Kidney External Relationships

The relations of the posterior surface of the kidneys are similar on both sides of the body, while the relations of the anterior surface of the kidney differ on the right and left. The kidneys lie on the psoas and quadratus lumborum muscles ***(Stoller and Meng, 2007)***.

Usually, the left kidney is higher than the right kidney, being the posterior surface of the right kidney crossed by the 12th rib and the left kidney crossed by the 11th and 12th ribs ***(Stoller & Meng, 2007)***.

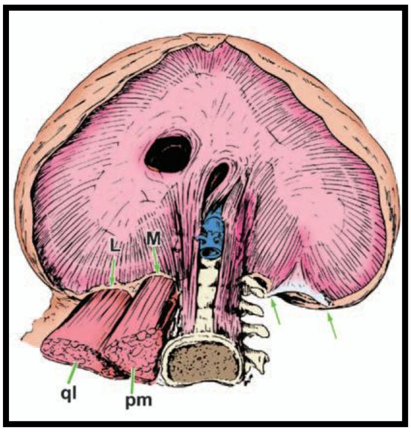


**Figure (3):** Schematic drawing of an inferior view of the diaphragmatic dome. The arrows point to the diaphragmatic attachments to the extremities of the 11th and 12th ribs. *M* = medial arcuate ligament, *L* = lateral arcuate ligament; *ql* = quadratus lumborum muscle; *pm* = psoas muscle ***(Sampaio, 2007)***.

The posterior surface of the diaphragm attaches to the extremities of the 11th and 12th ribs. Close to the spine, the diaphragm is attached over the posterior abdominal muscles and forms the medial and lateral arcuate ligaments on each side. In this way, the posterior leaves of the diaphragm arches as a dome above the superior pole of the kidneys, on each side. Therefore, when performing a percutaneous renal access, the endourologist may consider that the diaphragm is traversed by all intercostal punctures, and possibly by some punctures below the 12th rib ***(Sampaio, 2007)***.

Generally, the reflection of the parietal pleura extends inferiorly to the 12th rib paravertebrally; 10th rib at the mid-axillary line (MAL) and the 7th rib at the mid-clavicular line (MCL). Nevertheless, the lower most lung edge is covered by the visceral pleura which lies two intercostal spaces above the parietal pleural border (at the 10th intercostal space paravertebrally) ***(Stoller and Meng, 2007)***.

The adrenal glands rest on top of the kidneys medially against the cava on the right and aorta on the left.

On the right side, the anterior surface of the right kidney is associated with the liver superiorly, the curve of the duodenum over the midportion and the hepatic colic flexure inferior and medially.

On the left side, 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. The anteromedial surface of the entire left kidney is covered by the descending colon ***(Stoller and Meng, 2007)***.

It is important to consider the position of the retroperitoneal ascending and descending colons. Occasionally, it was observed in the course of routine abdominal CT scan examinations, that the retroperitoneal colon is lying in a posterolateral or even a postrenal position. Hence, in these cases, it is at great risk of being injured during the intrarenal percutaneous approach ***(Hopper et al., 1987).***

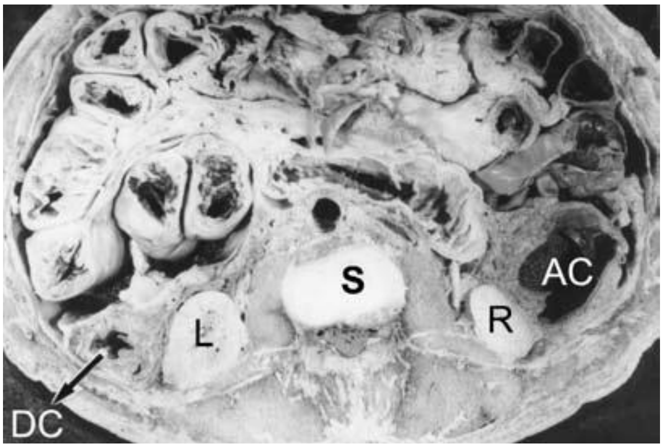


**Figure (4):** Superior view of a transverse section through a cooled cadaver at the level of the inferior poles of the kidney, reveals the ascending *(AC)* and descending *(DC)* colons lying in a posterolateral position in relation to right *(R)* and left *(L)* kidneys. *S* = spine ***(Sampaio, 2007)***.

It was demonstrated by CT scan that, when the patient is in the supine position, the retrorenal colon was found in 1.9%

of the cases. Nevertheless, when the patient assumes the prone position (the more frequent position used for percutaneous access to the kidney) the retrorenal colon was found in 10 % of the cases. This event (retrorenal colon) more commonly occurs with regard to the inferior poles of the kidneys ***(Hopper et al., 1987)***.

## Internal Architecture of the Kidney

The renal parenchyma consists of cortex &medulla. The glomeruli, proximal and distal convoluted tubules rest within the renal cortex, which is the outer layer of the renal parenchyma. The loops of Henle and collecting ducts rest within the renal pyramids, which together comprise the medulla of the renal parenchyma and rest within the center of the kidney ***(Stoller and Meng, 2007).***

The renal medulla is composed of multiple, distinct, conically shaped areas darker in color than the cortex called renal pyramids, the apex of the pyramid is the renal papilla, and each papilla is cupped by an individual minor calyx. While the renal cortex is lighter in color than the medulla and extends between the pyramids, the extensions of cortex between the renal pyramids are called the columns of Bertin, in which renal interlobar vessels traverse from the renal sinus to the peripheral cortex ***(Sampaio, 2000)***.