INTRODUCTION

The incidence of nephrolithiasis worldwide is approximately 1%. A recent study suggests that the prevalence of stone disease continues to rise, particularly in women, thought to be due to changes in diet and lifestyle. The recurrence rates for stone disease are high. After an initial stone, there is a 30% to 50% chance of forming a second stone within 5 years ***(Scales et al., 2007)***.

The Risk of renal stones is associated with multiple factors including sex, geographic region, diet, fluid intake, and socioeconomic status For example; urolithiasis is more prevalent in whites and is relatively rare in African Americans and Native Americans ***(Srivastava and Alon, 2005)*.**

Treatment of renal stones falls into 2 categories: observational and interventional. Medical management includes symptomatic treatment and aggressive hydration. Immediately, intravenous hydration at 1.5 to 2 times the maintenance rate is recommended. Pain associated with renal colic is best treated with narcotic analgesics combined with nonsteroidal anti-inflammatory medications ***(Safdar et al., 2006).***

The Common interventions include extracorporeal shockwave lithotripsy (ESWL), percutaneous nephrolithotomy (PCNL), endoscopy, open surgery, laprascopic and robotic. Extracorporeal shockwave lithotripsy is used with stones in various locations but is limited with larger lower pole stones, staghorn stones, and with the anatomically abnormal urinary tract ***(Dogan and Tekgul, 2007).***

Percutaneous nephrolithotomy is useful for large, lower pole stones, and staghorn stones ***(Beth and Bernadette, 2011).***

The percutaneous approach to the kidney has advanced to a remarkable degree since the first percutaneous nephrostomy was performed by ***Goodwin et al. in 1955.*** The procedure was done without benefit of imaging in a patient with gross hydronephrosis.Since then Percutaneous renal surgery has continued to have an important role in urology ***(Gupta et al., 2002).***

In addition to percutaneous nephrolithotomy, percutaneous renal access is often achieved for management of ureteropelvic junction obstruction, proximal ureteral stricture and upper collecting system tumors. Obtaining access through appropriate calyx is essential for satisfactory result ***(Gupta et al., 2002).***

The traditional subcostal access was preferred in percutaneous renal surgery to avoid injury to the lung and the pleura. However in some patients as those with upper caliceal stones, impacted upper ureteral stones, stag stones and in access to the ureteropelvic junction the supracostal approach provides the most direct access to achieve satisfactory result and the subcostal approach may fail to provide the optimal access ***(Gupta et al., 2002).***

The incidence of upper pole calculi is 15% of all caliceal calculi. The management of such calculi has been simplified since the advent of extracorporeal shock wave lithotripsy (ESWL). However, there is a subset of upper pole caliceal calculi where in certain features can render ESWL less than adequate treatment, namely, diameter > 1.5 cm, narrowing of the caliceal infundibulum, either singly or combined and morbid obesity ***(Lowry et al., 2004).***

In such instances, percutaneous nephrolithotomy (PCNL) is indicated; percutaneous success to an upper pole calyx can be difficult by a subcostal track. The supracostal 12th rib approach provides direct and efficient access to an upper pole calyx and is ideally suited for upper pole calculi ***(Lowry et al., 2004).***

In most cases of complete staghorn calculi, a lower pole puncture will provide access to the lower and upper pole branches, as well as the pelvic part of the stone. Using a flexible nephroscope or establishing a second percutaneous tract through the peripheral aspect of the stone may reach the midcalyceal part ***(Paul et al., 2002).***

There are, however, patients with staghorn calculi or with large-volume stones in compound calyceal configurations in the upper or lower pole in whom a supracostal upper-caliceal approach provides the best access for stone removal ***(Paul et al., 2002).***

A supracostal puncture is indicated when there is stones associated with ureteropelvic junction stricture requiring endopyelotomy especially secondary UPJ ostruction who had previously undergone open surgery without success ***(Okumura et al., 2002).***

The supracostal approach was avoided for fear of potential chest complications. However, orientation of pleural and diaphragmatic anatomy and refinement of the surgical technique reduces these complications to minimum ***(Nitin et al., 2001).***

AIM OF THE WORK

The aim of this work is to evaluate the safety and efficacy of supracostal access in percutaneous nephrolithotomy. We will try to standardize the indications of this approach, methods of prevention and early detection of potential complications, proper management of these complications and evaluation of the outcome in different situations.

ENDOUROLOGIC ANATOMY OF THE KIDNEY

General Anatomy:

The kidneys are paired organs lying retroperitoneal on the posterior abdominal wall. Each kidney is of a characteristic shape, having a superior and an inferior pole, a convex border placed laterally, and a concave medial border. The medial border of kidney has a marked depression, the hilum, containing the renal vessels and the renal pelvis ***(Drake et al., 2007).***

Position of the Kidneys:

As the kidneys lie on the posterior abdominal wall, against the psoas major muscles; their longitudinal axis parallels the oblique course of the psoas **(Figure 1).** Moreover, since the psoas major muscle has a shape of a cone, the kidneys also are dorsal and inclined on the longitudinal axis. Therefore, the superior poles are more medial and more posterior than the inferior poles. 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 **(Figure 2)** ***(Drake et al., 2007).***

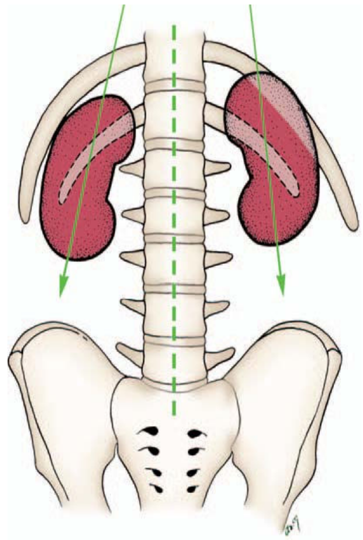

Figure (1): Anterior view of the kidneys in relation to the skeleton, shows that the longitudinal axis of the kidneys are oblique ***(Sampaio, 2000).***

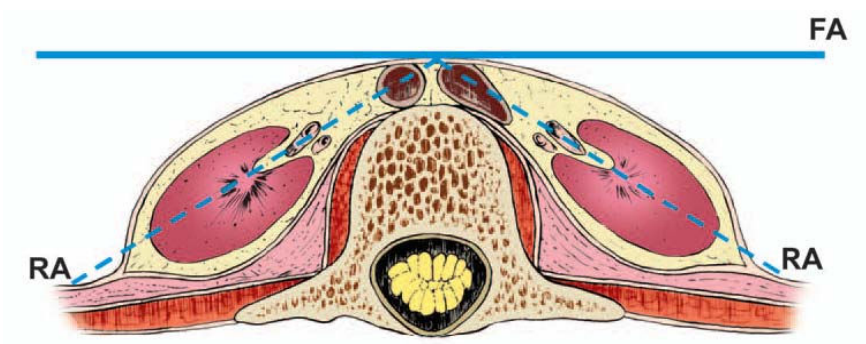

Figure (2): Superior view of a transverse section of the kidneys at the level of the 2nd lumbar vertebra ***(Sampaio, 2000).***

Perirenal Coverings:

The kidney surface is enclosed in a continuous covering of fibrous tissue called the "renal capsule" or "true renal capsule". Each kidney within its capsule is surrounded by a mass of adipose tissue lying between the peritoneum and the posterior abdominal wall called the perirenal fat **(Figure 2&4).** The perirenal fat is enclosed by the renal fascia (so-called fibrous renal fascia of Gerota's fascia). The renal fascia is enclosed anteriorly and posteriorly by another layer of adipose tissue, which varies in thickness, called the pararenal fat **(Figure 4)** ***(Sampaio, 2000).***

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 **(Figure 2 & 4).** The anterior and posterior layers of the renal fascia (Gerota's fascia) subdivide the retroperitoneal space in three potential compartments **(Figure 3).**

1. The posterior pararenal space, which contains only fat.
2. The intermediate perirenal space, which contains the suprarenal glands, kidneys and proximal ureters, together with the perirenal fat.
3. The anterior pararenal space, which unlike the posterior and intermediate spaces, 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 fused with the infra-diaphragmatic fascia. An additional fascial layer separates the suprarenal gland from the kidney. 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) **(Figure 2&4).** These anatomic descriptions of the renal fascia show that right and left perirenal spaces are potentially separated, and therefore, it is exceptional that a complication of an endourologic procedure (e.g., haematoma, urinoma, perirenal abscess) involves the contralateral perirenal space **(Figure 4)** ***(Drake et al., 2007).***

The true capsule and Gerota's fascia are of importance when performing a percutaneous renal surgery **(Figure 5).** As the needle is passed through the skin into the kidney, two areas of resistance are felt, the first is at the lumbodorsal fascia, and the second is at the true capsule. The renal capsule is a firm fibrous membrane that adheres to the underlying parenchyma. Passing the needle through this capsule is much like pushing a needle through cardboard in that there is some initial resistance to the needle's passage followed by sudden "give". At this point, the needle lies within the renal parenchyma and therefore moves upwards and downwards as the kidney moves with respiration ***(Sampaio, 2000).***

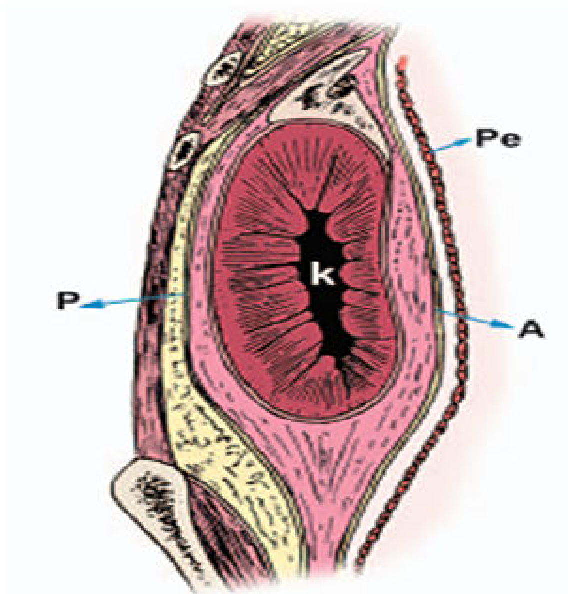

Figure (3): Lateral view of a longitudinal section through the retroperitoneum, reveals the posterior *(P)* and the anterior *(A)* layers of the renal fascia. *Pe* = peritoneum; *K* = kidney ***(Sampaio, 2000).***

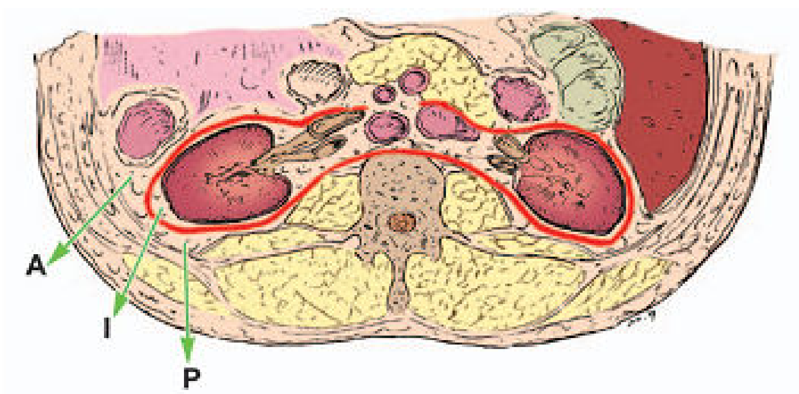

Figure (4): Superior view of a transverse section of the kidneys at the level of the 2^{nd} lumbar vertebra shows the three compartments of the retroperitoneal space ***(Sampaio, 2000).***

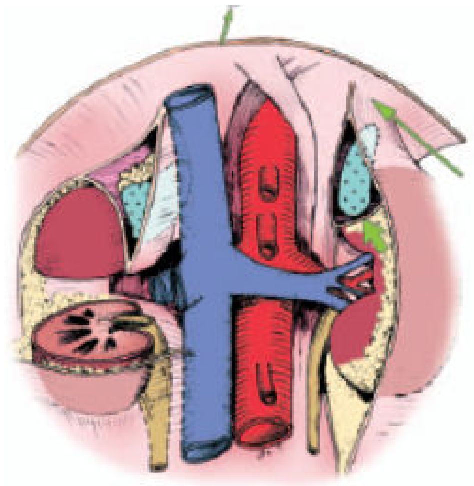

Figure (5): Anterior view of a schematic drawing of the renal fascia (Gerota's fascia) and the kidneys ***(Sampaio, 2000).***

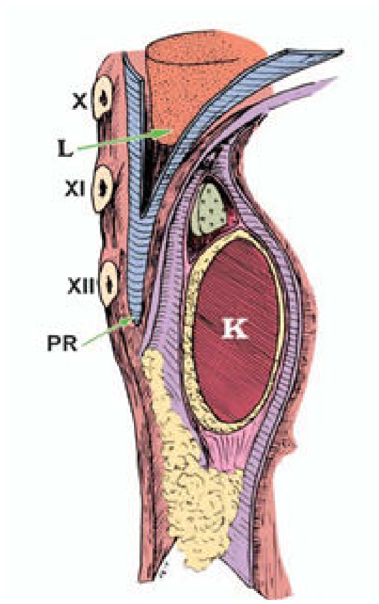

Figure (6): Schematic drawing from a lateral view of the kidney and its relationships with the diaphragm, ribs, pleura, and lung ***(Sampaio, 2000).***

Kidney Relationships with Diaphragm, Ribs, and Pleura:

The kidneys lie on the psoas and quadratus lumborum muscles, Usually, the left kidney is higher than the right kidney, therefore, the posterior surface of the right kidney is crossed by the 12th rib and the posterior surface of the left kidney by the 11th and 12th ribs. ***Wickham and Miller, 1983*** investigated the position of various calyces according to the 12th rib during maximum respiration with supine position and they found the following results (Table 1).

Table (1): Position of calyces in relation to the 12th rib

Calyces related to 12th rib	**Rt Kidney**	**Lt kidney**
Lower calyces below 12th rib	80%	78%
Middle calyces below 12th rib	42%	30%
Upper calyces below 12th rib	20%	15%

- ***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 abdominal muscles and forms the medial and lateral arcuate ligaments on each side. In this way, the posterior aspect of the diaphragm arches as a dome above the superior pole of the kidney on each side. Therefore, during intrarenal access by puncture, the endourologist may consider that the diaphragm is traversed by all intercostal punctures and possibly by some punctures below the 12th rib.

- ***The posterior reflection of the pleura*** extends inferiorly to the 12th rib so, it is punctured without symptoms in most intercostal approaches ***(Hopper and Yakes, 1990).***

- ***The lowermost lung edge*** lies above the 11th rib (at the 10th intercostal space) **(Figure 7)**. Regardless the degree of respiration (mid- or full-respiration), the risk of injury to the lung from a 10th intercostal percutaneous approach to the kidney is prohibitive ***(Hopper and Yakes, 1990).***

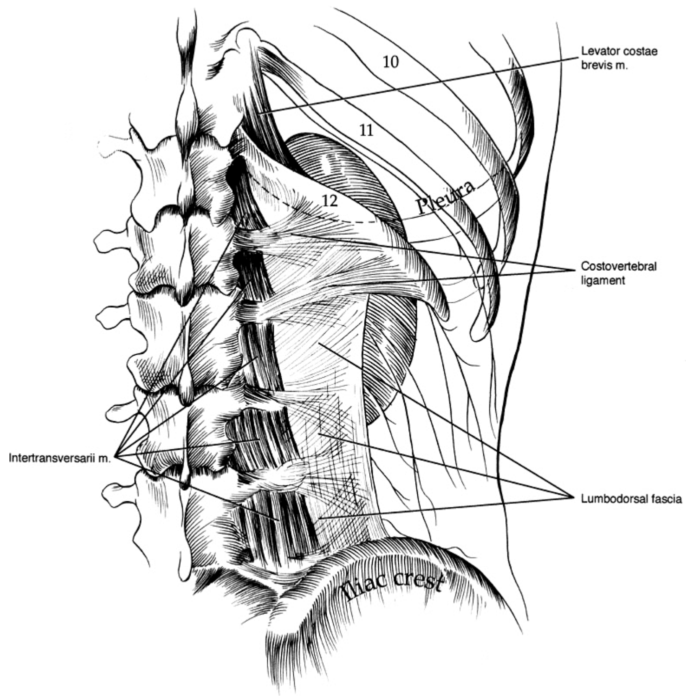

Figure (7): Laretral view of the kidney and its relationships with the diaphragm, ribs, pleura and lung ***(McDougall et al., 2002).***

Kidney Relationships with Liver and Spleen:

The liver on the right side and the spleen in the left may be posterolaterally positioned at the level of the suprahilar region of the kidney, because at this point, these organs have their larger dimensions**.** Therefore, one may remember that a kidney puncture performed high in the abdomen has little space for the needle entrance). If the intrarenal puncture is performed when the patient is in mid- or full inspiration, the risk to the liver and spleen is increased. This knowledge is particularly important in patients with hepatomegaly or splenomegaly, on whom a computed tomography (CT) scan should be performed before puncturing the kidney ***(Drake et al., 2007).***

Kidney Relationships with Ascending and Descending Colons:

The ascending colon runs from the ileocaecal valve to the right colic flexure (hepatic flexure), where it passes into the transverse colon. The hepatic colic flexure (hepatic angle), lies anteriorly to the inferior portion of the right kidney. The descending colon extends inferiorly from the left colic flexure (splenic flexure) to the level of the iliac crest. The left colic flexure lays anterolateral to the left kidney ***(Hopper et al., 1987).***

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 post renal position. Hence, in these cases, it is at great risk of being injured during the intrarenal percutaneous approach. This event (retro renal colon) more commonly occurs with regard to the inferior poles of the kidneys. In a controlled study, it was demonstrated by CT scan that, when the patient is in the supine position, the retro renal 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 retro renal colon was found in 10% of the cases ***(Hopper et al., 1987).***

Retrorenal colon

Potential risk factors for colonic perforation include thin, habitus, extremely lateral PCN tract (lateral to the posterior-auxiliary line), dilated pelvic-calyceal system, colonic obstruction, megacolon, kyphoscoliosis and a hyper-mobile kidney ***(Noor, 2004).***

In the large series of 15 colonic perforations, significant independent risk factors were advanced patient age (associated with reduced perinephric fat) and the presence of a horseshoe kidney 3–19% retro-renal colon ***(El-Nahas et al., 2006).***

More frequently retro-renal colon is noted on the left side and it is more likely to be situated near the inferior pole of the kidney ***(Hopper et al., 1987).***