

Introduction

Kidney stones (renal lithiasis) are hard deposits that form inside kidneys. Kidney stones are made of mineral and acid salts. Kidney stones have many causes. In one common scenario, kidney stones form when minerals inside the urine increased above the normal limit, crystallize and stick together (*Worcester, 2008*).

Kidney stones are a significant source of morbidity. Eighty percent of those with kidney stones are men. Men most commonly experience their first episode between ages 30-40 years, while for women the age at first presentation is somewhat later. Management of renal stones includes chemolysis, extracorporeal shock wave lithotripsy (**ESWL**), percutaneous nephrolithotomy (**PCNL**) and open surgery (*Miller and Lingeman, 2007*).

Percutaneous nephrolithotomy (**PCNL**) was established as a minimally invasive treatment option for removal of kidney stones in the 1970s and was further developed in the ensuing years (*Rassweiler et al., 1986*).

Furthermore, improvements in instruments (i.e., flexible nephroscopes and ureteroscopes) as well as lithotripsy technology (i.e., ultrasound/pneumatic devices,

holmium/yttrium-aluminum-granet laser)increased the efficacy of percutaneous nephrolithotomy for stone disintegration yielding stone-free rates of >90%**(Marguet et al., 2005).**

PCNL is generally a safe treatment option and associated with a low specific complication rate **(Rudnick & stoller, 1999).**

The creation of the nephrostomy tract is a fundamental step of percutaneous nephrolithotripsy (PCNL). Dilation of the track is usually achieved with multipleflexible exchange dilators of the Amplatz type, metal telescoping dilators of the Alken type, or a balloon dilator method**(Frattini et al., 2001).**

Multiple punctures that may be required in complex calculi may be better achieved with the sequential dilatation as balloon dilator has a single use,However it has been proven that sequential dilatation is associated with haemorrhage, increase operative time, fluoroscopic exposure time, perforation of the collecting system and increased morbidity**(Falahatkar et al., 2009).**

Balloon dilatation methods have been shown to decrease operative time, the rate of haemorrhage and fluoroscopic exposure time,Howeverballoon dilatation method havehigh cost effectiveness**(Michel et al., 2007).**

When sequential dilatation is used to create an access, the access needs to be dilated repeatedly. Such dilation is based on repeated and direct friction with the renal parenchyma; it

is therefore a “sharp” dilation. During balloon dilation, the balloon and the renal cortex have relatively fixed locations and compress each other horizontally at a single attempt, thus reducing repeated and direct friction with renal parenchyma, bringing less injury to the renal parenchyma, and decreasing intraoperative blood loss(*Mohhta et al., 2008*).

Patients using balloon dilatation method had a lower incidence of postoperative fever than the sequential dilatation method, possibly because patients in the balloon dilatation method had less intraoperative bleeding. The more intraoperative bleeding means more broken vascular stumps in the kidney, which provide the most direct path for the irrigation and the bacteria, endotoxins, and pyrogen released by bacteria can easily back-flow into the bloodstream, which results in postoperative fever(*Li et al., 2013*).

Although the balloondilation system is safe and effective to establish percutaneous renal access, the success rate drops dramatically in patients with prior renal surgery owing to postoperative adhesions which makes the balloon dilatation very difficult to gain access to the kidney(*Falahatkar et al., 2009*).

Aim of the Work

The aim of this work is to compare between balloon dilatation and sequential dilatation during percutaneous nephrolithotomy regarding:

- 1- Efficacy (tract dilatation time).
- 2- Safety (transfusion rate, hemoglobin decrease, radiation exposure and complications).
- 3- Cost effectiveness.

ANATOMY OF THE KIDNEY

The kidneys are paired, reddish brown, solid organs that lie well protected deep within the retroperitoniem, on the either side of the spine(*Kabalin et al.,1992*).

they lie in the retroperitoneal space underneath the diaphragmatic muscle in the paravertebral (costovertebral) gutter and extend from the 12th thoracic vertebra to the third lumbar vertebra with its long axis parallel to the psoas muscle and the lordotic curvature of the lumbar vertebrae (*Grunberger, 1997*).

As a result, the upper pole of the kidney, which is closely related to the adrenal gland, is more posterior and nearer to the median plane than in the lower pole, because of the size and position of the right lobe of the liver, the right kidney is approximately 1.5 cm lower than its counterpart. The anatomic axis of the kidney is rotated to 30° posterior to the coronal plane of the body (*Grunberger, 1997*).

They are paired organs.Each adult kidney is approximately 11 cm long, 6 cm wide and 3 cm thick, is normally bean-shaped and has a lateral convexity(*Grunberger, 1997*).

The normal kidneys in the adult male weighs approximately 150 gm. on the average, it is slightly smaller in females, weighing approximately 135 gm. Also the size in females is lower than that of males, but kidney dimensions are related more to overall body size rather than to sex, with smaller individuals having generally smaller kidney mass than larger individuals(*Kabalin et al., 1992*).

Perirenal coverings:

The renal surface is covered by a thin fibrous capsule (also referred as the true capsule) and is surrounded by connective and adipose tissue, which is collectively called perirenal fat. Perirenal fat is enveloped in the anterior and posterior reflections of the perirenal fascia (Gerota's fascia) Figs (1). This fascia merges superiorly with the diaphragmatic fascia above the adrenal gland, laterally with the fascia covering the paracolic gutter, medially with the fascia covering the muscles, and anteriorly with the dense fascia covering the major vessels, pancreas, mesentery, and duodenum on the right side. These fascial reflections determine the extent and path of spread of the perinephric and paranephric collections (*Rptopoulos et al.,1999*).

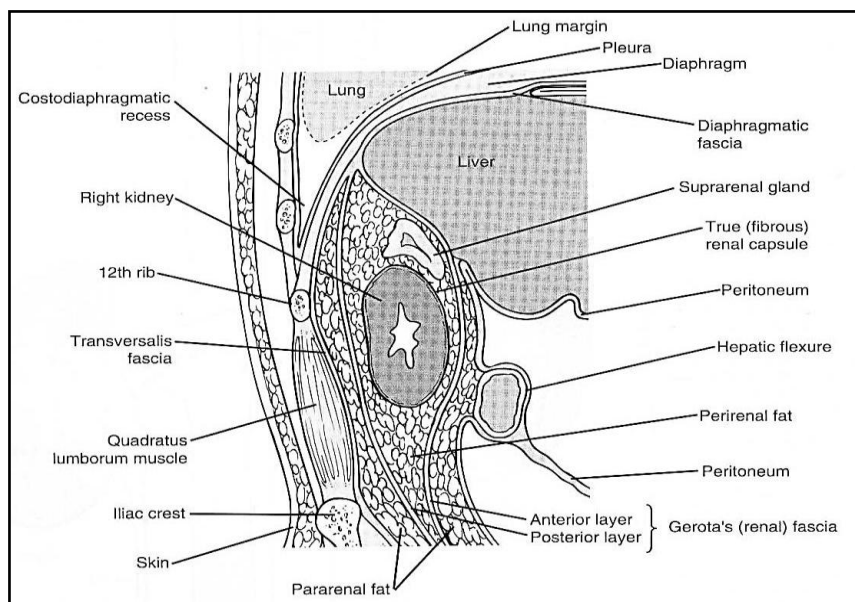


Figure (1): Sagittal view demonstrating Gerota's fascia and its merger with diaphragmatic fascia above. Also note the renal relations with the diaphragm, 12th rib, costodiaphragmatic pleural recess, and the colon(Quoted from *Burkill &Healy 2000*).

Anterior relationships:

The anteromedial aspect of the superior pole of each kidney is covered by the corresponding adrenal gland, The right kidney is related to the liver superiorly, the descending portion of the duodenum medially, and the hepatic flexure lies on the anterior aspect of lower pole, The left kidney is bounded anteriorly by the stomach and spleen at superior pole and splenic flexure at inferior pole. The tail of pancreas lies immediately anterior to the left renal hilum (*sampaio, 1993*).

Posterior relationships:

Posteriorly, the upper pole of the right kidney is related to the 12th rib, whereas the upper pole of the left kidney is related to 11th and 12th ribs due to its higher position. Diaphragmatic fibers originating from the 12th rib separate the inferior margin of the parietal pleura (costodiaphragmatic recess) from the upper half of the posterior surface of the left kidney and the upper third of the posterior surface of the right kidney. A puncture of the renal collecting system above the 12th rib can, therefore, lead to pneumothorax and hydrothorax (*Kaye, 1982*).

The lateral convex renal border (related to the spleen, the descending colon, and the peritoneum on the left side and the right lobe of the liver on the right) is posterior to the medial concave border, which includes the renal hilum (*Coleman 1987*).

As the intercostal vessels and nerves run along the inferior margin of the rib, a puncture close to the lower rib margin should be avoided to prevent the risk of pain and hemorrhage. Occasionally, when the 12th rib is absent or short, the 11th rib can be mistaken for a 12th rib, leading to an inadvertent puncture of the pleura and injury to the lung.

Careful study of the status of the 12th rib prior to the puncture avoids such a mishap. During inspiration, the lower lung margin descends into the pleural recess, whereas during expiration, it moves away from the pleural reflection. A supracostal renal puncture should therefore be performed under fluoroscopy in expiration to avoid injury to the lung (*Grunberger1997*).

The kidneys are approximately 2.5 cm lower in the standing position and move downward during inspiration and upward during expiration. Cranial displacement during inspiration and caudal displacement during expiration of the extracorporeal segment of a percutaneously inserted needle therefore confirms its presence within the kidney (Fig. 2)However; the renal movements during respiration are either restricted or lost in patients who have had previous retroperitoneal surgery(*Grunberger, 1997*).

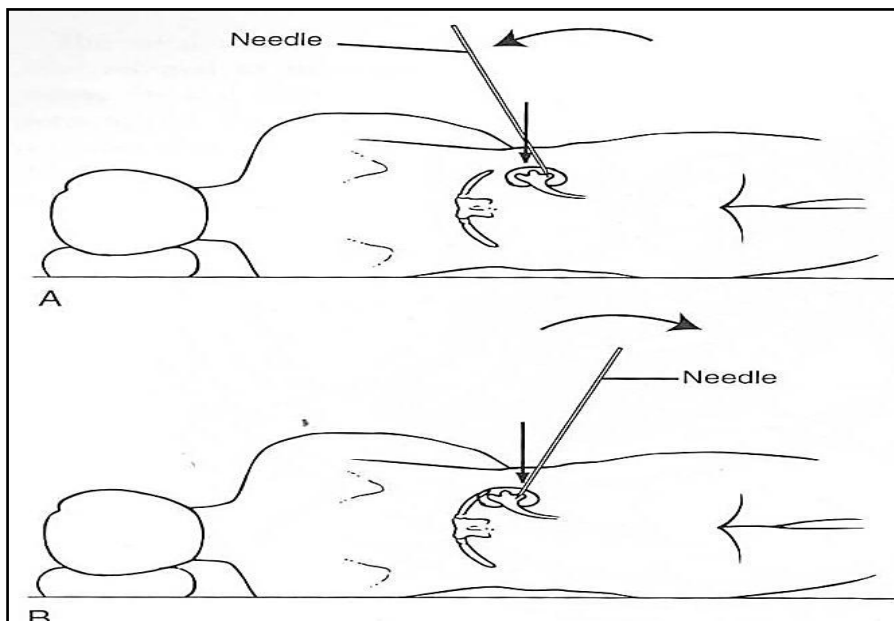


Figure (2): A caudal displacement of the extracorporeal segment of a percutaneous needle during expiration. B, Cranial displacement of the extracorporeal segment of a percutaneous needle during inspiration(Quoted from Grunberger, 1997).

Kidney Relationships with Ascending and Descending Colons

The ascending colon runs from the ileocolic 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 lies anterolateral to the left kidney. 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. This event (retrorenal colon) more commonly occurs with regard to the inferior poles of the kidneys (Figure 3)(*Hooper et al.,1987*).

In a controlled study, it was demonstrated by CT scan that, when the patient is:

- **Inthe supine position**, the retrorenal colon was found in 1.9% ofthe cases.
- **In the prone position**, (the more frequent position used for percutaneous access to the kidney) the retrorenal colon was found in 10% of the cases.

Therefore, special attention should be given, under fluoroscopy and with the patient in the prone position, to detecting patients with retrorenal colon prior any invasive percutaneous renal procedure. This examination is especially important in the area of the inferior poles of the kidneys(*Hooper et al., 1987*).

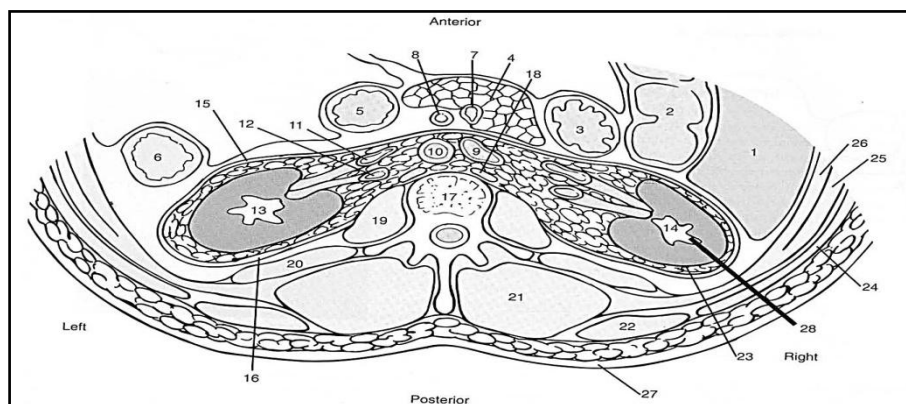


Figure (3): Transverse section at the 12 vertebral level. The line at No 28 indicates the preferred path for the creation of a percutaneous renal tract through the posterolateral muscle. Key: 1, liver 2, hepatic flexure 3, duodenum 4, pancreas 5, duodenojejunal junction 6, descending colon 7, superior mesenteric vein 8, superior mesenteric artery 9, inferior vena cava 10, aorta 11, renal vein 12, renal artery 13, left kidney 14, right kidney 15, anterior layer of Gerota's fascia 16, posterior layer of Gerota's fascia 17, lumbar vertebra 18, crus of diaphragm 19, psoas major muscle 20, quadratus lumborum 21, erector spinae muscle 22, latissimus dorsi muscle 23, true renal capsule 24, external oblique 25, internal oblique 26, transversus 27, skin 28, preferred path for creation of nephrostomy (Quoted from *Burkill &, Healy J.C (2000)*).

Cases with increase incidence of colon injury during PCNL:

- **Elderly people and thin people:** the increased risk of colonic injury may be attributed to posterior displacement of the colon owing to the decreased amount of perinephric fat (*hadar and gadoth, 1984*).
- **Horseshoe kidney:** developmental anomalies with horseshoe kidneys result from the absence of the kidney from its normal position that leads to postrenal displacement of the colon (*Skoog et al., 1985*).

- **Left kidney:** the descending colon was more posterior to the lower pole of the kidney, this increase incidence of colonic injury especially with lower calyceal approaches(*Hopper et al., 1987*).
- **Previous intestinal bypass surgery:** owing to the presence of colonic distention(*Wolf, 1988*).
- **Previous renal surgery:** owing to adhesions(*Wolf, 1988*).

Precautions to avoid perforation of the colon during pcnl:

- 1- *Alken et al (1981)* advocatedultrasound –guided puncture of the pelvicalceal system. it is helpful because if the colon interferes between the skin puncture and the kidney, the skin puncture site can be changed.
- 2- *Matlga et al (2003)* introduced CT- guided pucture of the pelvicalyceal system in patiens with anatomic abnormalities that precluded standardised access to the collecting system without risk of injury to adjacent organs.
- 3- Under fluoroscopic – guided PCNL, indentation of the gas shadow within the distended colon can be seen if the needle punctures it and the direction of the needle can be readjusted or the site of skin pucture can be changed to avoid the colon(*El-Nahas et al., 2006*).

Early diagnosis and management are the key for avoiding complications from colonic perforation. Therefore, antegrade nephrostogram at the end of each PCNL procedure was advised to identify any unnoticed colonic perforation (*El-nahas et al., 2006*).

Renal vasculature:

The renal artery arises from the aorta and before it enters the hilum it divides into segmental arteries. Fig (4) Segmental arteries are end arteries and do not anastomose with each other. Brödel's description of a bloodless line of incisions located just behind the convex border of kidney represented a division between the anterior and the posterior arterial segments(*Sampaio, 1991*).

This line, which was considered avascular for a long time, is in fact vascular because of the presence of venous arcades and interdigitation between the peripheral arteries from the anterior and posterior segments (*Graves, 1986*).

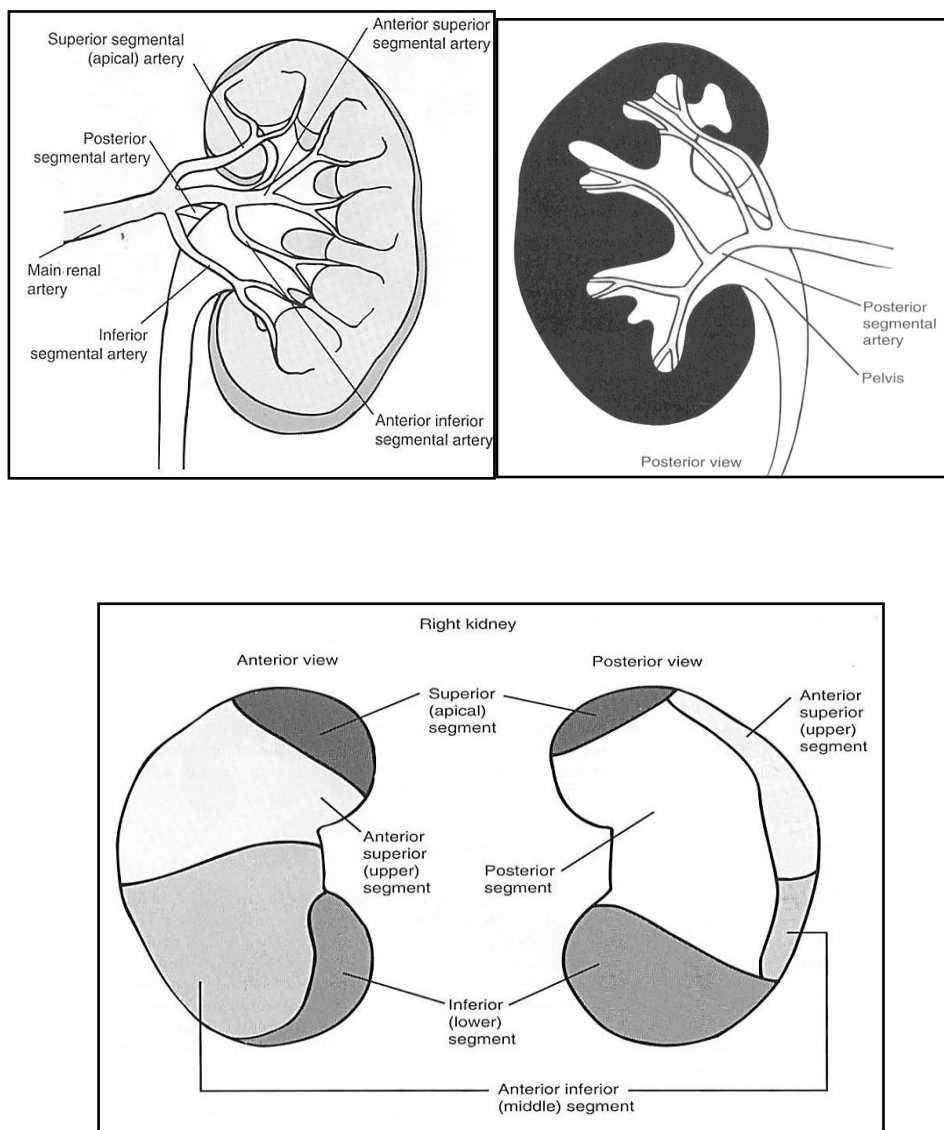


Figure (4): Arterial supply of the kidney(*Quoted from gupta et al., 2007*)

Unlike the arteries, renal veins do not follow a segmental pattern and anastomose freely with one other, forming relatively large venous anastomotic plexuses around