INTRODUCTION

Extracorporeal shock wave lithotripsy (ESWL) is the recommended treatment for renal stones up to 20mm in diameter ***(Kangjam et al., 2013).***

There is a considerable variability in reported treatment results of ESWL with success varying from 60% to 90% ***(Elkoushy et al., 2011).***

Disintegration is the first step in the treatment of renal stones by ESWL, the magnitude of response of a calculus to disintegration (i.e. stone fragility) should be considered before using ESWL. It is often not possible to predict whether a given stone is amenable to fragmentation by shock waves before starting treatment; however there are many factors that affect stone fragility, such as size and composition ***(Williams et al., 2003).***

The success rate is influenced by stone factors (stone size, location, composition, degree of obstruction), clinical factors (symptom severity, patient's expectations, associated infection, solitary kidney, abnormal ureteral anatomy), and technical factors (available equipment, cost) ***(Lingeman et al., 2010).***

Non contrast computed tomography (NCCT) has become the preferred modality for the diagnosis of renal calculi owing primarily to its rapidity and high accuracy. NCCT has been evaluated for use not only for the diagnosis of stones but also for the prediction of ESWL treatment results ***(Park et al., 2012).***

Skin to stone distance (SSD) can be readily measured by CT scan; the ESWL stone-free rate was inversely proportional to SSD in renal stone patients. SSD may therefore be a useful clinical predictive factor of the success of ESWL on renal stones ***(Park et al., 2012).***

In patients with a Stone attenuation value >1000 Hounsfield unit (HU), ESWL should not be considered to patients as a first treatment, especially in those with a body mass index (BMI) >30 and lower calyceal stones. As failure would be expected in more than half, together with the need for many sessions, this will increase the treatment-related morbidity with little cost benefit ***(Massoud et al., 2014).***

Abdominal obesity was traditionally evaluated with parameters such as the BMI and waist-to-hip circumference ratio. BMI and HU density was significant independent predictors of calculus-free rates following ESWL ***(Mezentsev et al., 2005).***

AIM OF THE WORK

Evaluation of (body mass index, skin to stone distance and Hounsfield units) as single predictive factor or in combination on outcome of extracorporeal shock wave lithotripsy for adult patient with renal stone

PELVICALYCEAL ANATOMY

Renal parenchyma is divided into two major parts: superficial is the renal cortex and deep is the renal medulla. Grossly, these structures arranged as 8 to 18 cone-shaped, each containing renal cortex surrounding a portion of medulla called a renal pyramid of Malpighi. Between the renal pyramids there are projections of cortex called renal columns of Bertin ***(Clapp, 2009).***

Nephrons are the functional structures of the kidney, that consist of:

1) Renal corpuscle, which is the initial filtering portion of a nephron located in the cortex.

2) Renal tubule that passes from the cortex deep into the medullary pyramids. a medullary ray is a collection of renal tubules that drain into a single collecting duct.

3) The papilla, of each pyramid empties urine into a minor calyx.

4) Minor calyces empty into major calyces.

5) Major calyces empty into the renal pelvis, which continue as the ureter. **Fig. (1)** ***(Clapp, 2009).***

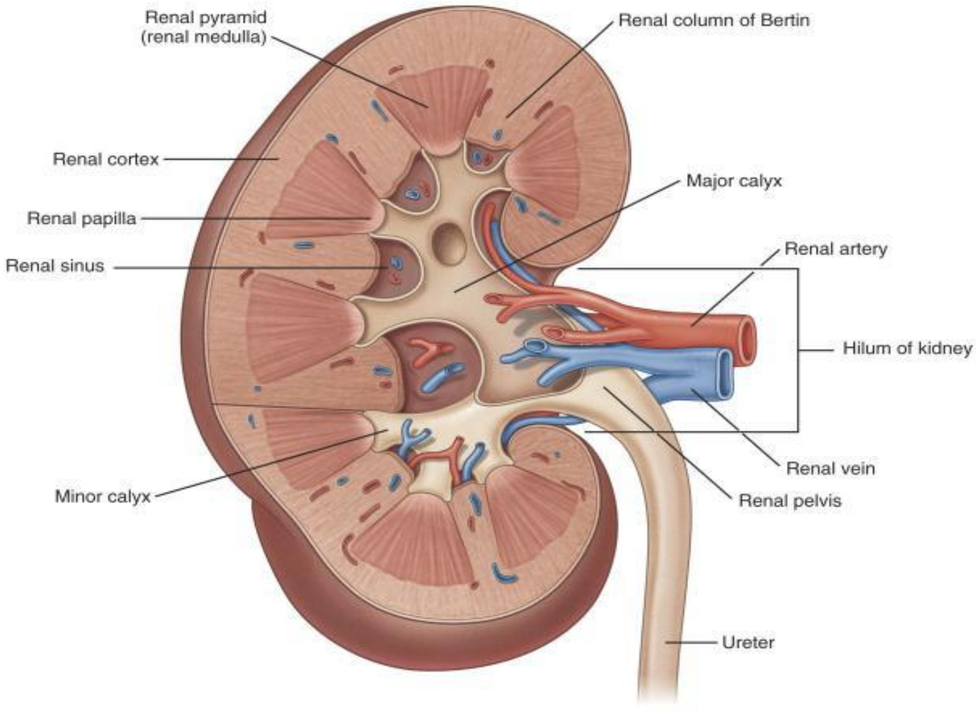


Fig. (1): Internal structure of the kidney ***(Drake et al., 2005).***

There are typically two longitudinal rows of renal pyramids and corresponding minor calyces, roughly perpendicular to one another extending anteriorly and posteriorly. The minor calyces are the first structures of the gross renal collecting system ***(Jung et al., 2006).***

The kidneys do not lie in a simple coronal plane, but the lower pole of each kidney is pushed slightly more anterior than the upper pole. In addition, the medial aspect of each kidney is rotated anteriorly at an angle of about 30° from the true coronal plane. This rotation tends to displace the posterior renal calyces directly posterior and anterior renal calyces more lateral ***(Christopher and William, 2011).***

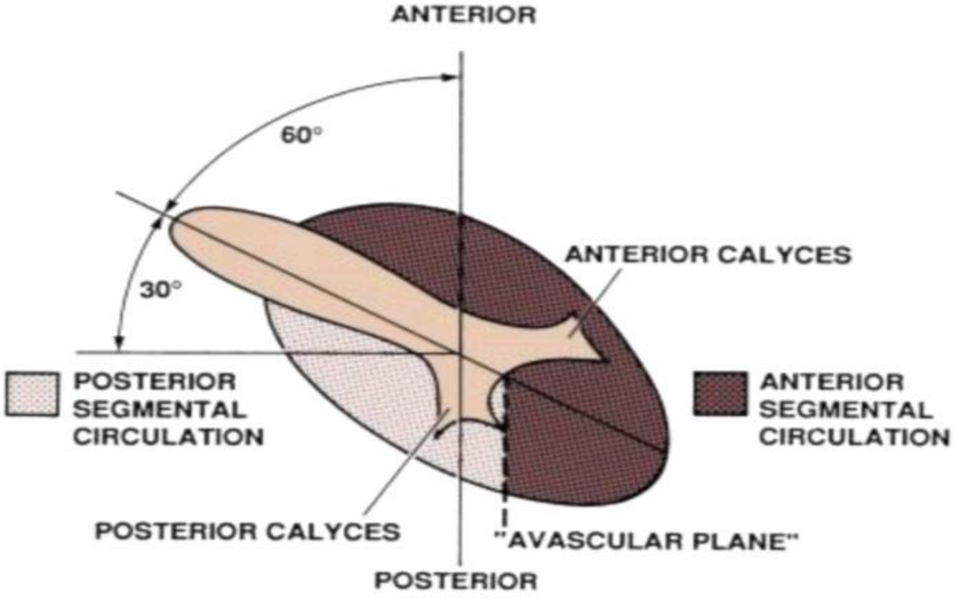


Fig. (2): Normal rotational axis of the kidney ***(Drake et al., 2005).*** Transverse view showing approximate 30-degree anterior rotation of the left kidney from the coronal plane, relative positions of the anterior and posterior rows of calyces, and location of the relatively avascular plane separating the anterior and posterior renal circulation. *Quoted from John & Kabalin: Campbell's Urology.9th ed (2007).*

It is common that some renal pyramids fuse during development, thus forming compound papillae. This often occurs at the renal poles but can occur throughout the kidney. Such compound papillae result in larger, compound calyces **(Fig.3)**. The compound papillae permits urinary reflux into the renal parenchyma with sufficient back pressure. The minor calyces narrow, creating a neck or infundibulum before joining other minor calyces to form usually two to three major calyces, which in turn coalesce in most individuals to form a single renal pelvis ***(Kabalin, 2002).***

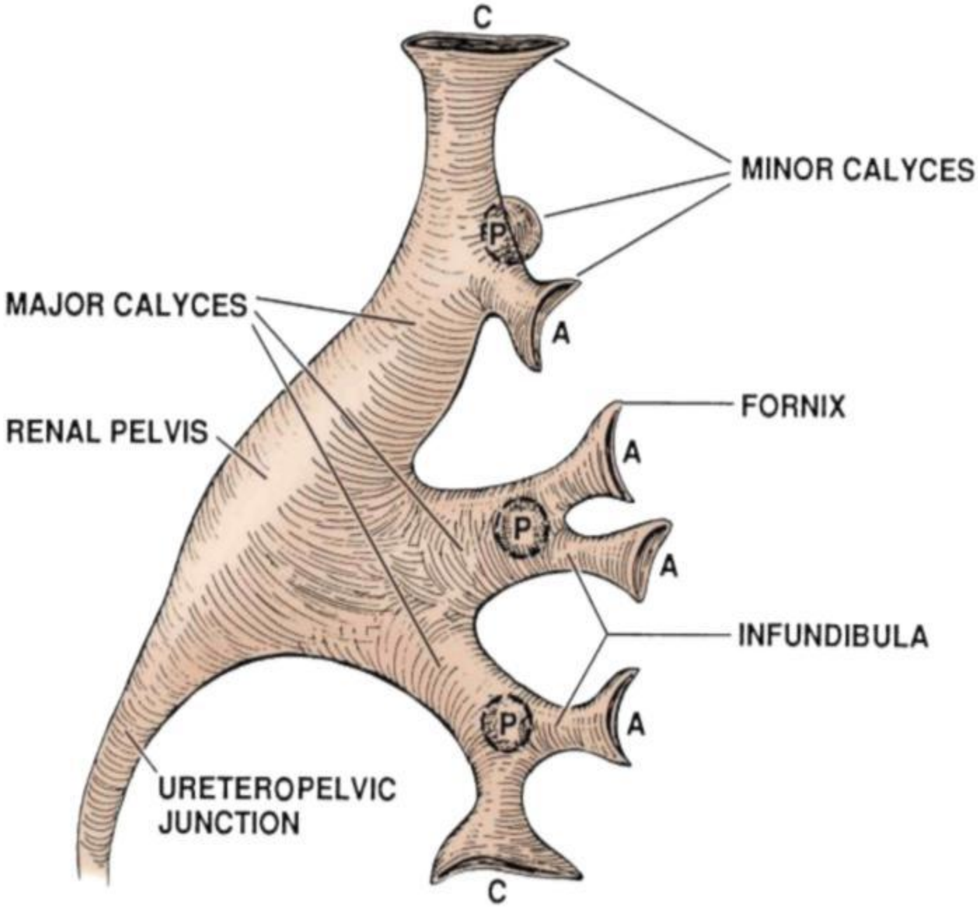


Fig. (3): The renal collecting system (left kidney) showing major divisions into minor calyces, major calyces, and renal pelvis. **A**, anterior minor calyces; **C**, compound calyces at the renal poles; **P**, posterior minor calyces. ***Kabalin (2002)***: Quoted from Campbell'sUrology. 10th ed

Infundibulopelvic angel

Lower pole stones have been consistently associated with lower stone free rates following ESWL when compared with upper and middle pole stones as the tendency for stones to remain in dependent portions of the collecting system owing to gravity regardless of the degree of fragmentation ***(Glenn et al., 2011).***

Various measurements of the lower pole dimensions were proposed to have an effect on outcome of ESWL, such as the Lower Pole Infundibulopelvic Angle, and the infundibular length and width, the Lower Infundibulopelvic Angle, has the greatest impact clearance **(Fig.4)**, followed by infundibular length **(Fig.5)**, an angle more than 70 and a length less than 5 cm yield the best clinical result ***(Glenn et al., 2011).***

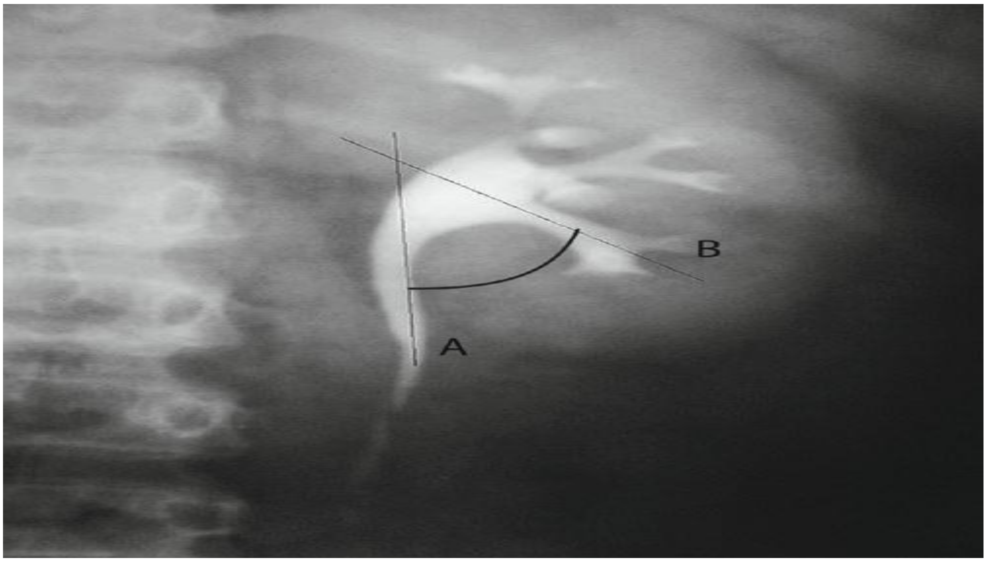


Fig. (4): The lower infundibulopelvic angle is the angle between the ureteropelvic axis (**A**) and the vertical axis of the lower infundibulum (**B**) ***(Nagaraja et al., 2011).***

Infudibular width appears to be associated with more favorable outcome when >5 mm. this measurements can be easily measured of standard IVP film and thus be used to select ESWL as a treatment modality with a predictably favorable outcome in individual cases **(Fig.5)** ***(Glenn et al., 2011).***

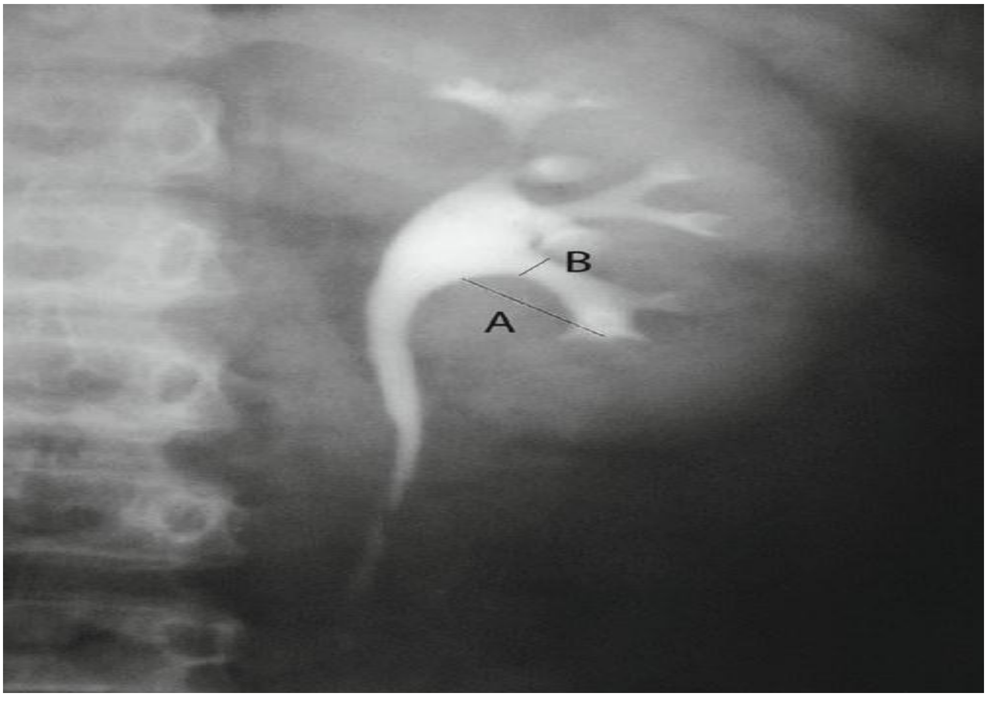


Fig. (5): Lower pole infundibular length **(A)** is measured as the distance from the most distal point at the bottom of the calyx harboring the stone to the midpoint of lower lip of renal pelvis. The infundibular width **(B)** is measured at the narrowest point of the lower pole infundibulum ***(Nagaraja et al., 2011).***

RENAL STONE COMPOSITION

Stone composition affects the pattern of stone response to shock waves and hence the percentage of stones fragmented with a given number of shock waves ***(Gücük and Üyetürk, 2014).***

Determination of renal stone composition is important for two reasons:

1) Composition is related to hardness, which affects the outcome of ESWL.

2) Stones related to various metabolic syndromes, such as cystine stones or uric acid stones may require systemic medical treatment. So that, knowing the stone composition enables some preventive efforts (dietary restrictions, drug treatment) ***(Niewada et al., 2014).***

How to determine stone composition:

For years there are many effort to predict stone composition by analyzing the metabolic status, searching for microcrystals in urine sediment, and finally by means of radiological examinations. In the most cases minerals found in crystals from urine sediment corresponded to those found in stones. However, the accuracy of these methods is not sufficient enough to use them in clinical practice. Additionally, stones are usually not composed of monocrystals and even two stones made up of the same minerals may different in fragility because of their structural variability ***(Niewada et al., 2014).***

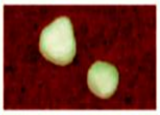
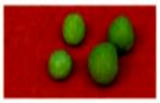
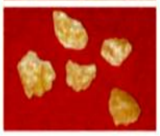
Determination of the stone composition are based on patient history, previous stone analysis of the patient or HU in NCCT ***(Türk et al., 2015).***

Since 1980, NCCT has been studied as a possible useful tool to predict stone composition through density measurements (Hounsfield Units) which have been used during diagnosis to predict the type and opacity of renal stones, and the efficacy of using ESWL in treatment ***(Gücük and Üyetürk, 2014).***

Types of urinary Calculi:

The most common component of urinary calculi is calcium, which is a major constituent of nearly 75% of stones. Calcium oxalate makes up about 60% of all stones; mixed calcium oxalate and hydroxyapatite, 20%; and brushite stones, 2%. Both uric acid and struvite (magnesium ammonium phosphate) stones occur approximately 10%, whereas cystine stones are rare (1%) (Table 1). Stones associated with medications and their by products such as triamterene, adenosine, indinavir, silica and ephedrine are uncommon and usually preventable ***(Cakıroglu et al., 2014).***

Table (1): Chart illustrates commonly occurring urinary tract stones and describes their salient features. KUB = kidney, ureter, bladder ***(Kambadakone et al., 2010).***

	Composition	Frequency of Occurrence	KUB Radiographic Appearance	CT Appearance/Attenuation (HU)	Associated Etiologic Factors
	Calcium oxalate monohydrate and dihydrate (calcium oxalate dihydrate)	40%–60%	Radiopaque	Opacified/ 1700–2800	Underlying metabolic disorder (eg, idiopathic hypercalcuria or hyperoxaluria)
	Hydroxyapatite (calcium phosphate)	20%–60%	Radiopaque	Opacified/ 1200–1600	Usually no metabolic abnormality
	Brushite	2%–4%	Radiopaque	Opacified/ 1700–2800	. . .
	Uric acid	5%–10%	Radiolucent	Opacified/ 200–450	Idiopathic hyperuricemia or hyperuricosuria
	Struvite	5%–15%	Radiopaque	Opacified/ 600–900	Renal infection
	Cystine	1%–2.5%	Mildly opaque	Opacified/ 600–1100	Renal tubular defect

A) Calcium stones:

Eighty to eighty-five percent of all renal stones are calcareous. Calcium nephrolithiasis is most commonly due to elevated urinary calcium, a decreased level of urinary citrate, elevated urinary uric acid or elevated urinary oxalate ***(Stoller, 2012).***

Hypercalciuria is found in combination with other defects in 18 % and as a solitary defect in 12% of patients ***(Stoller, 2012).***

ESWL of dihydrated renal calcium oxalate stones tend to fragment into tiny parts which may be easily passed. On the other hand, calcium oxalate monohydrate stones and dihydrated calcium phosphate stones (brushite) tend to produce larger fragments which are hence much harder to pass ***(Addessi et al., 2012).***

B) Non Calcium Stones:

1. Struvite stones:

Struvite stones are composed of magnesium, ammonium and phosphate. which are radio opaque on plain films, formed in alkaline urine and association with urinary tract infection by urea splitting bacteria including Pseudomonas, Proteus, Providencia, Mycoplasma, Klebsiella, Staphylococci ***(Frassetto and Kohlstadt, 2011).***

Struvite stones characterized by their large size and rapidly growth, 4-6 week may be sufficient for a struvite stone formation and subsequently develop into staghorn stones which most common composed of struvit and calcium carbonate apatite ***(Sean and Brain, 2011).***

Renal stones made by Struvite, uric acid and dihydrated calcium oxalate tend to fragment into tiny parts by ESWL that may be easily passed ***(Addessi et al., 2012).***

2. Uric acid stones:

Uric acid stones compose <5% of all urinary calculi and are usually found in men. Patients with gout, myeloproliferative diseases, or rapid weight loss, and those received cytotoxic drugs treatment for malignant conditions have a high incidence of uric acid nephrolithiasis ***(Stoller, 2012).***

Uric acid stones are the most common radiolucent renal stones which can detected with NCCT and have high recurrence rate. Three major types of renal stone found in patients with uric acid nephrolithiasis are:

1) Pure uric acid stone.
2) Mixed stone containing uric acid and some other components, such as ammonium urate and sodium urate.
3) Mixed stone containing only uric acid and calcium oxalate which formation involved the nucleation and growth of calcium oxalate monohydrate crystals ***(Li et al., 2015).***

Uric acid nucleation is facilitated in the presence of calcium, the surface of uric acid stone is usually covered with calcium oxalate which is hard to dissolve in the alkali solution. The ESWL prior to the urinary alkalization using sodium bicarbonate helps in removal of the calcium oxalate shield and facilitate the dissolution ***(Li et al., 2015).***