Sudan University of Science and Technology

College of Graduate Studies

A Comparative Study between Spiral Computed Tomography and Ultrasound in Detecting Urolithiasis

مقارنة بين فحص الأشعة المقطعية الحلزونية وفحص الموجات فوق الصوتية لتحديد الحصى البولية

A thesis Submitted for partial Fulfillments of the requirements of M.Sc. in Diagnostic Radiological Technology

By:

Mazza Mustafa Ibrahim Alnour

Supervisor:

Dr. Hussien Ahmed Hassan

2019

الآيـة

بِسۡمِ ٱللَّهِ ٱلرَّحۡمَٰنِ ٱلرَّحِيمِ

(وَلَقَدْ خَلَقْنَا الْإِنْسَانَ وَنَعْلَمُ مَا تُوَسْوِسُ بِهِ نَفْسُهُ وَنَحْنُ أَقْرَبُ إِلَيْهِ مِنْ حَبْلِ الْوَرِيدِ)

صدق الله العظيم

سورة ق الآية (16)

Dedication

To my parents

To my husband

To my friends

To my teachers

To who supported me

To everyone who wishes me success.

With love and gratitude

I dedicate this work

Acknowledgements

Firstly we praise Allah, who blessed me with knowledge.

I deeply grateful to my supervisor: **Dr. Hussein Ahmed Hassan**, for supplying me with essential information and for encouragement.

I also thanks Asia Hospital, Ahmed Gassem Hospital and Modren Medical Center for the great helpful.

Abstract

The study was cross sectional study of spiral computed tomography and ultrasound to demonstrate the diagnostic value of computed tomography in diagnosing presence and absence of urolithisiasis and identifying whether computed tomography and ultrasound can lead to accurate diagnosis of urolithiasis and compare between computed tomography and ultrasound in detection of urolithiasis, conducted in Khartoum state in (Asia Hospital, Ahmed Gassem Hospital and Modren Medical Center), from August to October 2019.

The data was collected from 100 patients classified and analyzed using SPSS and the study found that males are more affected by urolithiasis than females (68- 32) respectively, so the age group between(31-40) are more exposed to urolithiasis. The study concluded that the presence of urolithiasis in kidney is detected by both modalities in higher frequency than singular modality and the presence of urolithiasis in bladder is better detected by computer tomography.

The presence of urolithiasis in smallest valid of size (< 5mm) is better detected by ultrasound, the presence of urolithiasis in (5mm- 10mm) is better detected by computed tomography and the presence of urolithiasis in (> 15mm) is better detected by computed tomography.

مستخلص الدراسة

دراسة مقطعية للتصوير المقطعي الحلزوني والموجات فوق الصوتية لإظهار القيمة التشخيصية للتصوير المقطعي المحوسب في تشخيص وجود حصى المسالك البولية وعدم وجودها، وتحديد ما إذا كان التصوير المقطعي والموجات فوق الصوتية يمكن أن يؤدي إلى تشخيص دقيق لمجرى البول والمقارنة بين التصوير المقطعي والموجات فوق الصوتية في الكشف عن حصى المسالك البولية ، أجريت في ولاية الخرطوم في (مستشفى آسيا ، مستشفى أحمد قاسم ومركز مودرن الطبي) ، من أغسطس إلى أكتوبر 2019.

تم جمع البيانات من 100 مريض تم تصنيفها وتحليلها باستخدام SPSS ووجدت الدراسة أن الذكور أكثر عرضة للإصابة بمرض البولية من الإناث (68− 32) على التوالي ، وبالتالي فإن الفئة العمرية بين (31−40) معرضة أكثر لمجرى البول. وخلصت الدراسة إلى أن وجود الحصى البولية في الكلى يتم اكتشافه بواسطة كلتا الطريقتين في وتيرة أعلى من الطريقة المفردة وأن اكتشاف وجود الحصى البولية في المثانة هو أفضل من خلال التصوير المقطعي المحوسب.

يتم الكشف عن وجود الحصى البولية في حجم صغر يقدر بحوالي (> 5مم) عن طريق الموجات فوق الصوتية ، لكن من الأفضل كشفها عن طريق الموجات فوق الصوتية (5−10مم) يفضل الكشف عن طريق التصوير المقطعي ووجود الحصى البولية (< 15مم) يفضل الكشف عن طريق صور الأشعة المقطعية.

List of Contents

Topics	Number
الاية	I
Dedication	II
Acknowledgements	III
Abstract	IV
مستخلص الدراسة	V
List of Contents	VI
List of Figures	VIII
List of tables	IX
List of abbreviations	X
Chapter One	
1.1 Introduction	1
1.2 Objectives	3
1.2.1 General Objectives	3
1.2.2 Specific Objectives	3
1.3 Hypothesis	3
Chapter Two **Theoretical Background and Previous Studies**	
2.1 Anatomy	4
2.1.1. The kidneys	5
2.1.2 The ureters	6
2-1-3 Urinary bladder	6
2.1.4 Urethra	7
2.2 Pathological considerations	7
2.2.1 Calculi	7
2.2.2 Urolithiasis	7
2.2.3Types of urinary tract calculi	8
2.2.4 Etiology of primary urolithiasis	9
2.2.5 Effects of calculi	10
2.3 Radiological and medical imaging considerations	11
2.3.1 Ultrasonography [U/S]	11
2.3.1.1. Ultrasound physics principles	11
2.3.1.2 Display of ultrasound images	12
2.3.1.3 Ultrasound Technique	13
2.3.1.4 Ultrasound artifacts	14

2.3.1.6 Advantages of Ultrasound	14
2.3.1.5 Disadvantages of Ultrasound	15
2.3.2 Computed tomography [CT]	15
2.3.2.1 Principle of CT	15
2.3.2.2 Spiral CT physics	16
2.3.2.3 The attenuation values	18
2.3.2.4 CT Technique	18
2.3.2.5 CT artifact	19
2.3.2.6 Advantages of spiral CT	20
2.3.2.7 Disadvantages of spiral CT	20
2.4 previous studies	21
Chapter three **Methodology**	
3.1Martials	22
3.1.1 type of study	22
3.1.2 Area of study	22
3.1.3 Duration of study	22
3.1.4 Population of study	22
3.1.5 Study variables	22
3.2 Methods	22
3.2.1 Subjects and clinical evaluations	22
3.2.2 CT procedure	23
3.2.3 U/S procedure	23
3.2.4 Equipment	24
3.2.5 Data analysis	24
3.2.6 Data presentation	24
3.2.7 Data storage	25
3.2.8 Ethical consideration	25
Chapter four **Results**	
Results	26
Chapter five **Discussion, Conclusion and Recommendation**	
5.1 Discussion	35
5.2 Conclusion	37
5.3 Recommendations	38
References	39
Appendix	41

List of Figures

Figures	Page No.
(2-1) shows the anatomy of urinary system and Relationships	4
(2.2) shows anatomy of the kidney and blood supply.	5
(2-3) shows anatomy of the urinary bladder and urethra.	6
(2.4) shows spiral CT mechanism	16
(2.5) shows gantry component including slip-rings technology	17
Figure (4.1): Participants distribution with respect to gender	26
Figure (4.2): Participants distribution with respect to age	27
Figure (4.3): Participants distribution with respect to method	28
Figure (4.4): Participants distribution with respect to urolithiasis site	29
Figure (4.5): Participants distribution with respect to urolithiasis size	30
Figure (4.6): Participants distribution with respect to urolithiasis density	31
Figure (4.7): Distribution participants' urolithiasis size with respect to method	32
Figure (4.8): Distribution participants, urolithiasis site with respect to method	33
Figure (4.9): Distribution participants, urolithiasis density with respect to method	34

List of Tables

Table	Page No
Table (4.1): Participants distribution with respect to gender	26
Table (4.2): Participants distribution with respect to age	27
Table (4.3): Participants distribution with respect to presence	28
Table (4.4): Participants distribution with respect to urolithiasis site	29
Table (4.5): Participants distribution with respect to urolithiasis size	30
Table (4.6): Participants distribution with respect to urolithiasis density	31
Table (4.7): Distribution participants' urolithiasis size with respect to method for CT and U/S	31
Table (4.8): Distribution participants' urolithiasis size with respect to method	32
Table (4.9): Distribution participants, urolithiasis site with respect to method	33
Table (4.10): Distribution participants, urolithiasis density with respect to method	34

List of abbreviations

Abbreviation	Term
A. mode	Amplitude mode
B. mode	Brightness mode
CT	Computed tomography
FOV	Field of view
HU	House field unit
KUB	Kidney, ureter and bladder
KV	Kilo voltage
M. scan	Motion scan
MAS	Milliamper in second
MHZ	Mega hertz
PZT	Piezoelectric
SPSS	Static package of social since
US	Ultrasound
UVJ	Uretro-vesical junction
WL	Window level
WW	Window width

Chapter One

Chapter One

1.1 Introduction

Renal calculi are very common. The most common calculi are calcium stones (Ca oxalate or Ca phosphate). Other types are straiten stones, uric acid stones, cysteine stones, matrix stones and xanthine stones. Many of them have mixed compositions. Men are more commonly affects than women. Renal calculi are usually asymptomatic. Urethral calculi present with acute colicky flank pain radiating to groin, dysuria, hematuria, dull/sharp pain radiating to penis. Most of the calcium stones are idiopathic (Albert A. Moss et al, 1992).

(Albert A. Moss et al, 1992), Calculus > 0.7 cm indicates obstruction; however it is not very specific or sensitive finding. Bladder calculi occur most commonly as a result of either migration from the kidney or urinary stasis in bladder (secondary to bladder outlet obstruction, cystocele and neurogenic bladder). Bladder calculus is seen as mobile, echogenic focus with posterior shadowing. Stones which are secondary to urinary stasis are usually large. When the etiology is bladder outlet obstruction diffuse bladder wall thickening may be noted. Rarely stones can adhere to the bladder wall due to adjacent inflammation and these are known as hanging bladder stones.

Ultrasonography has become increasingly important technology for the detection of renal calculi. The sensitivity of ultrasonography is slightly superior to that of plain abdominal films. The renal calculi are detected by their marked echogenicity and associated acoustic shadowing. The minimal size of calculus that are detected or identified is at least 0.5 cm.

with a transducer between 2.25 and 3.5 MHz Transducers in the range of 6-10 MHz are able to detect renal calculi as small as 3 mm (G.Marchal et al, 2005).

Renal ultrasonography offers anatomical details without exposure to radiation or contrast material. The protection of the renal calculus is based on the presence a of highly echogenic focus with posterior acoustic shadowing of the stone. Renal ultrasonography is a useful screening tool for the demonstration of renal stones and evaluation of hydronephrosis in patients with suspected renal calculi, also is useful for patients where intravenous contrast or radiation is contraindicated. However, ultrasound is seldom utilized in the initial evaluation of patient with flank pain (Hsieh, Jiang.2009).

In other hand Computed Tomography (CT) Scan has assumed a greater and increasing importance with regard to urolithiasis. It has the ability to detect radiolucent calculi such as uric acid stones. Unlike ultrasounds, helical CT Scans can image the entire ureter and differentiate among the various causes of ureteral obstruction. Therefore, both radial opaque and non-opaque stones in the ureter can easily be demonstrated and to identify the cause for ureteral obstruction by CT scan. CT scan can detect stones as small as 3 mm (Jerrold T. Bushberg et al, 2002).

A spiral or helical CT has gained widespread acceptance at numerous institutions as becoming the imaging modality of choice for studying patients with suspected urinary calculi. But the CT scan had limitations like: it can't provide direct physiologic information in patient with kidney stone and unable to identify very small stone when it smaller than image matrix size (Jerrold T. Bushberg et al, 2002).

1.2 Objectives

1.2.1 General Objectives:

To compare spiral computed tomography and ultrasound in detecting urolithiasis.

1.2.2 Specific Objectives:

Demonstrate diagnostic value of computed tomography.

To find out computed tomography sensitivity and specificity.

To identify whether computed tomography can leading to accurate diagnosis of urolithiasis.

To compare between computed tomography and ultrasound to detecting urolithiasis.

1.3 Hypothesis

Spiral CT is more efficient than U/S in imaging renal stones.

Chapter Two

Literature Review and Previous Studies

Chapter Two

Literature Review and Previous Studies

2.1 Anatomy:

The urinary system concerned with excretion of the waste products of metabolism and of foreign substances from body, the maintenance of a normal water balance and normal balance of electrolytes such as sodium, Potassium, calcium, etc. in the blood and tissue fluids. In the exercise the kidney are concerned with maintenance of a normal reaction (acid –base balance) in the blood and tissue fluids (Jerrold T. Bushberg et al, 2002).

The urinary system consists of following structure:

1. The kidneys are excretory organs.
2. The ureters are the ducts draining the kidneys.
3. The urinary bladder is urinary reservoir.
4. The urethra is channel to the exterior.

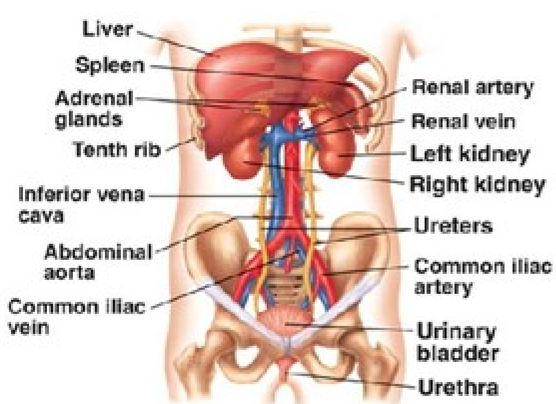


Figure (2-1): shows the anatomy of urinary system and relationships (William R. Hendee et al, 2002).

2.1.1. The kidneys:

The kidneys are pair of organ, each of which is about 11 cm (4.25 in) length, 6 cm (2.5 in) width and 3 cm (1.25in) thicknesses. They lie obliquely rather than vertically, with their upper poles nearer than their lower poles to the midline, behind the peritoneum of the posterior abdominal wall. The right kidney is about 1.25 cm lower than the left and its lower pole may sometimes be felt on examination of normal subjects during full inspiration. The kidney move up and down with respiration and are about 2.5 cm (1 in) lower in the standing position than in the recumbent position. The average weight of the adult kidney is about 150g in the male and 135g in female. The kidneys are dark red in color, and bean-shaped.

Each kidney has anterior and posterior surface, superior and inferior poles, and a lateral convex and a medial concave border. In the center of medial border is a notch known as hilum, which contain the renal blood vessels and nerves and the renal pelvis, which is the funnel-shaped upper end the ureter (Jerrold T. Bushberg et al, 2002).

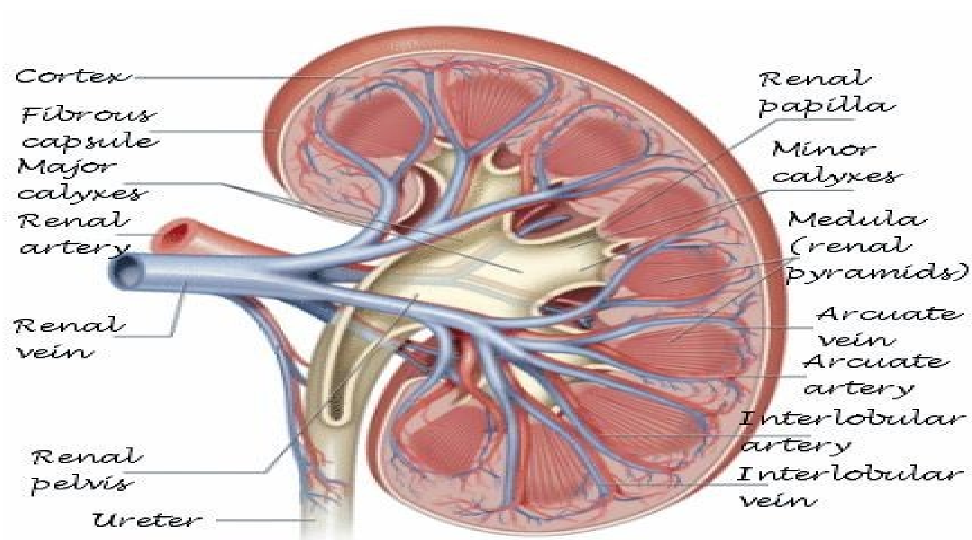


Fig (2.2): shows anatomy of the kidney and blood supply (Henry Grey, Warren H Lewis, 2000).

2.1.2 The ureters:

The ureter is duct which conveys the urine from the kidney to the bladder. The pelvis of the ureter is its upper expanded portion, which lies mainly in the anterior of the kidney. It commences as a number of funnel-shaped channels, which surround the papillae of pyramids and are called calyces. The ureter is a tube about 26 cm (10 in) length, consists of an outer fibers coat, a middle muscular layer and an inner layer of transitional epithelium (K. Subburaj, 2011).

2-1-3 Urinary bladder:

Bladder is reservoir for the urine received from kidneys via the ureter. It's a muscular sac lined by mucous membrane covered with transitional epithelium. The bladder must be considered in its two extreme states, empty and full. The empty bladder lies behind the pubic symphysis. As it fills, the neck remains fixed whilst the superior surfaces rises above the symphysis pubic and the infero-lateral surface become the anterior surface of the now ovoid bladder, and resting against the anterior abdominal wall (K. Subburaj, 2011).

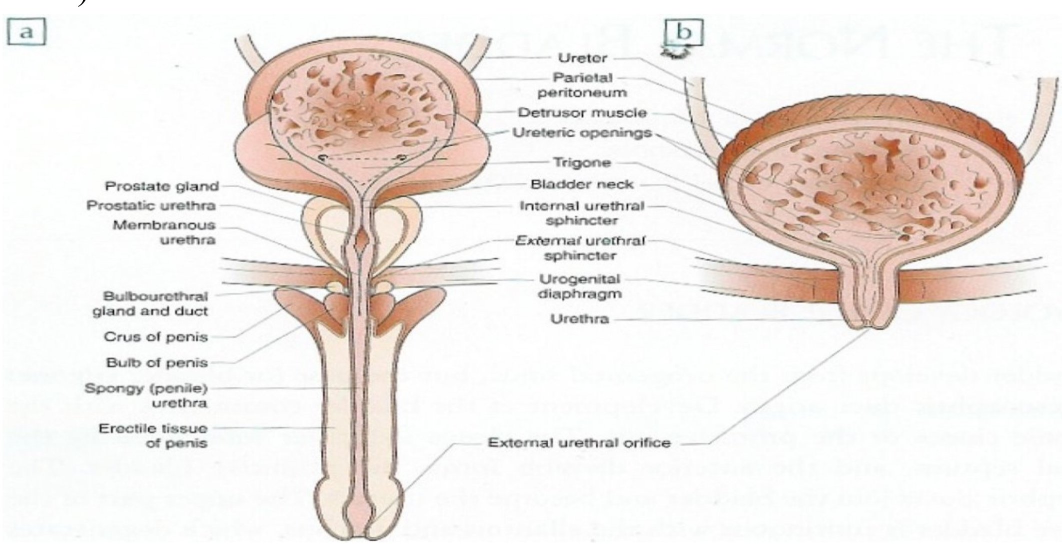


Fig (2-3): shows anatomy of the urinary bladder and urethra (Jain E Gillespie, T.J. Thompson, 1983).

2.1.4 Urethra:

The urethra is canal conveying the urine from the bladder to exterior. It differ in the two sexes and its main function in the male is reproductive. The male urethra is about 20 cm, and female are 4 cm (K. Subburaj, 2011).

2.2 Pathological considerations:

2.2.1 Calculi:

A calculus is a mass of precipitated material derived from a secretion and deposited in an excretory duct. The mode of calculus formation is obscure. It's usually assumed that in any secretion the crystalloid are hold in solution by absorption on to colloidal particles, and that when the concentration of crystalloids increases or the colloidal content decreases, the crystalloids will precipitate out. The colloidal matrix in which the crystalloid of low molecular weight deposit varies according to secretion; in urinary calculi it consists mostly of muco-protein and muco-polysaccharide with smaller amount of plasma proteins (G.Marchal et al, 2005).

2.2.2 Urolithiasis:

Urolithiasis is calculus formation at any level in collecting system, but the most often the calculi arising in kidney. They occur frequently as evidenced by the finding of stones in about 1% of all autopsies. Almost of renal stones are composed of either calcium oxalate or calcium oxalate mixed with calcium phosphate. A few of another renal stones composed of magnesium, ammonium, phosphate, uric acid and cysteine stones (Albert A. Moss et al, 1992).

2.2.3Types of urinary tract calculi

1. Calcium oxalate stones

Calcium oxalate stones are associated with patients of both hypercalcema and hypercalciuria occasioned by hyperparathyroidism, diffuse bone disease, sarcoidosis and other hypercalcemia status. The mechanism of stones formation in this setting involves nucleation of calcium oxalate by uric acid crystals in the collecting duct. The patient with hyperoxaluria either herditery "primary oxaluria" or more commonly, acquired by intestinal over absorption in patients with entric diseases, later so called entrichyperoxaluria. Also occur with patients their diet is rich in oxalate. Hypocitrauria associated with acidosis and chronic diarrhea of unknown cause may produce calcium stone.

2. Magnesium ammonium phosphate stone

These are formed largely after infection by urea splitting bacteria. Which convert urea to ammonium. The resultant alkaline urea causes the precipitation of magnesium ammonium phosphate salts. These form some of the largest stones, as amount of urea created normally are huge.

3. Uric acid stone

These are very common in patient with hyperuricemia such as gout and diseases involving rapid cell turnover such as leukemia. However, most patients with uric calculi have neither hyperuricemia nor an increased urinary excretion of uric acid. It's thought that an unexplained tendency to excrete urine of PH below 5.5 may predispose to uric acid stones. Because uric acid insoluble in relatively acidic urine. In contrast uric acid stones are radioleucent.

4. Cysteine stone

These are caused by genetic defect in renal reabsorption of amino acid, including cysteine, leading cysteine urea. Stones formed at low urinary PH (Hsieh, Jiang.2009).

2.2.4 Etiology of primary urolithiasis:

The majority of primary urinary calculi arise in an unknown way, but a few factors are worthy of consideration:

1. Increased content of crystalloid [abnormal crystalloid] in urine:

Metabolic disorders of xanthinuria and cystinuria it is understandable that poorly soluble in substances like cysteine and xanthine should precipitate out of solution with great rapidity.

2. Dehydration: is an important factor in the etiology of renal stone. It is advisable to encourage individuals with a tendency to stone formation to drink large amounts of water. Urinary calculi occur more commonly in tropical climates, but the saturation is often complicated by presence of local infection, e.g. schistosomal cystitis.

3. Foci of calcification in the kidney acting as a nidus for calculus formation.

Foci of dystrophic calcification in renal papilla arising secondarily to injury; these ulcerated through the pelvic mucosa and acted as a nidus for calculus formation.

4. Renal microliths: small flecks of calcium salts are present in the interstitial tissue of all kidneys and are properly situated in renal lymphatics. These microliths might coalesce to form calculi.

5. Stasis and obstruction are lead to secondary calculus formation because it predisposes to infection.

Ureteric calculi are usually renal in origin, as are also many vesical calculi. Stones may also be produce in bladder as result of severity, persistent cystitis secondary to obstruction to the outflow of urine, or in narrow-necked diverticula. They also formed around foreign bodies introduced from outside, e.g: piece of catheter and safety pins.

2.2.5 Effects of calculi:

The calculiare often silent, and are discovered accidentally during radiological examination, they may produce definite pathological effects:

1. Pain: the sudden distention or the spasm of hallow muscular viscous produced by stone leads to pain. The urinary calculi by abrading the mucosa also cause haemorrhage.

2. Obstruction: ureteric or renal calculi may cause obstructive to outflow of urine, it May be partially or completely.

3. Infection (G.Marchal et al, 2005).

2.3 Radiological and medical imaging considerations:

2.3.1 Ultrasonography [U/S]:

Ultrasonography is a diagnostic procedure employing high frequency sound waves. The technique is frequently used as the examination of choice but may also be employed as a complement to other diagnostic procedures.

The frequency of sound waves used in medical diagnosis may be between 1 and 15 MHz, 2 to 10 MHz being the most useful and practical frequencies (R.bruening et al, 2006).

2.3.1.1 Ultrasound physics principles:

Ultrasound is generated in pulses from a transducer consisting of a disc of (PZT), which has piezo-electric properties.

When a voltage is placed across the disc, it creates a pulse of high frequency sound waves. The interfaces of different body tissues reflect the ultrasound as echoes. Ultrasound waves pass through the body in straight lines and they reflected and refracted at the interfaces between the various structures of the body (R.bruening et al, 2006).

The echoes consist of mechanical vibrations which ted by it in to electrical impulses. These impulses are amplified and displayed in cathode-ray oscilloscope or TV monitor and can then photographed.

During scanning, the transducer is usually in contact with the patient's skin. To achieve satisfactory ultrasonic coupling, a thin layer of aqueous gel is first spread over the skin to act as coupling medium (R.bruening et al, 2006).

2.3.1.2 Display of ultrasound images:

1. 'A' Mode (amplitude modulation scan):

The returning echoes, as electrical impulses, are made to displace vertically the horizontal time-base on the cathode ray screen. The amount of vertical displacement is proportional to the strength of the echoes from interfaces along the ultrasound beam. 'A' mode is one-dimensional display (R.bruening et al, 2006).

2. 'M' Scan(motion scan):

It develops from the 'A'-mode scan, but the returned echoes are recorded as bright dots along a time-base. M–Scanning makes possible observations of moving structures during specific time interval. M–Scanning is extensively used in echocardiography (R.bruening et al, 2006).

3. 'B' mode(Brightness modulated scan):

The static 'B'_ mode, the returning echoes are displayed as dots. The distance between the dots is representation of the depth of the reflecting interfaces within the body (R.bruening et al, 2006).

The direction of the scan line on the display corresponds to the orientation of the transducer. 'B'_ mode information is displayed as grey scale which depicts the amplitude of returning echoes in varying shades of grey black and white (R.bruening et al, 2006).

4. Real-time scan (two dimension scan):

A real time scanner is produces images at a fast frame speed that allows movement to be followed. Fast frame rate are achieved either mechanically moving a single transducer or group of transducer elements, or electronically switching a row of transducer element (R.bruening et al, 2006).

2.3.1.3 Ultrasound Technique:

A 3 to 5 MHz sector/linear transducer are used to scan the urinary tract. Although no specific preparation is require for scanning the kidneys, optimizes the visualization. Evaluation of the renal vessels is augmented by adequate patient hydration, and a full bladder is essential for visualizing the lower ureters,vesico-ureteric junction, and the bladder.

The kidneys are scanned in the supine or lateral decubitus position. Varying the degree of respiration can help incomplete evaluation of the kidney is more difficult to visualize because gas in small bowel and splenic flexure interfere with the interior or antero-lateral approach. A postero-lateral approach often gives a good visualization of left kidney.

Scanning in prone position is rarely required in adults, except for renal guidance procedures, but in young children it remains a useful approach.

The proximal ureters are best visualized in coronal oblique view, using the kidney as a window. The distal ureters can be seen supra pubically through the full.

The urinary bladder is scanned trans-abdominally using 3 to 5 MHz transducers or trans-perennially using 7 to 10 MHz transducers. Endocavitary high frequency probe (trans-rectal/ transurethral) can give excellent details of the bladder wall (Ramsay Vallance et al, 1999).

2.3.1.4 Ultrasound artifacts:

1. Acoustic enhancement: Better ultrasound transmission allows enhancement of the ultrasound signal distal to that region.

2. Acoustic shadowing: Occurs distal to any highly reflective or highly attenuating surface and important diagnostic clue seen in a large number of medical conditions such as biliary stones, renal stones and tissue calcifications.

3. Lateral cystic shadowing (edge artifact): A type of refraction artifact.

4. Wide beam artifact: occur from gas bubbles.

5. Side lobe artifact: More than one ultrasound beam is generated at the transducer head.

6. Reverberation artifact: Several types and caused by the echo bouncing back and forth between two or more highly reflective surfaces

7. Gain artifact.

8. Contact artifact: Caused by poor probe-patient interface.

2.3.1.5 Advantages of Ultrasound:

1. Good anatomical detail of the kidney in a short period of time.

2. No exposure to radiation.

3. No use of intravenous contrast agents.

4. Ultrasound is regarded as safe in obstetric patients (R.bruening et al,2006).

2.3.1.6 Disadvantages of Ultrasound:

1. Poor visualization of calcifications or obstructing stones in the ureter.

2. Lack of assessment of renal function.

3. The need for a full bladder to properly visualize stones at the ureteral vesicle junction (UVJ).

4. Limited role in the diagnosis of other pathology in the absence of a ureteral calculus (R.bruening et al, 2006).

2.3.2 Computed tomography [CT]:

2.3.2.1 Principle of CT:

Computed tomography, like conventional radiography, relies on x-ray transmitted through the body. Computed tomography differs from conventional radiography in that it uses a more sensitive x-ray detection system than photographic film, namely gas or crystal detectors, and manipulates the data using computer. The x-ray tube and detectors rotate around the patient, and the patient lies with part to be examined within the gantry housing. By the moving the patient through the gantry, multiple adjacent section can be imaged allowing a picture of the body to be built up (Thorsten M. buzug, 2008).

There are two method of CT scanning:

1. Slice -by- slice "conventional CT": In this method the table top supporting the patient comes to a stop for each section.

2. Spiral "helical" CT: the patient is transported continuously through the scanner, so in effect the x-ray beam traces a spiral path, while the data are

collecting continuously, to create "volume of data" within the computer memory (William R. Hendee et al, 2002).

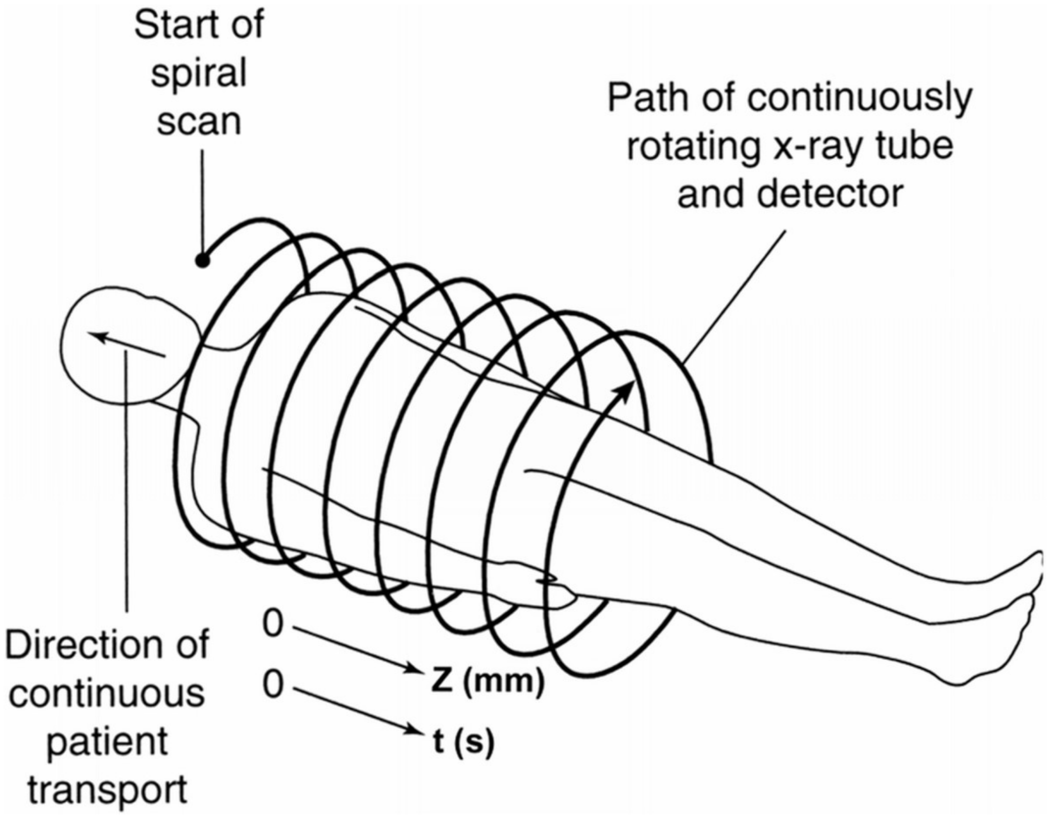


Fig (2.4) shows spiral CT mechanism (JamescD.mace, Nina Kowalczyk 2001).

2.3.2.2 Spiral CT physics:

The advances enable CT data to be acquired continuously with on-going patient movement:

1. Slip-ring technology

Slip ring technology was the fundamental step that allowing volume data acquisition. In older "conventional" CT system, there was an inherent delay of 3-5 seconds between each exposure. This arose from the physical need to have cables connecting the stationary gantry and the rotating x-ray tube, detector systems, and control system. It depending on cable length, the cable become wound and rotation of the tube-detector assembly had to stop, and change direction. These may lead to mechanical problems. Slip-ring technology abolished the physical need for presence of an electrical cable between the generator and moving tube-detector assembly. Power is transmitted between the stationary and moving rings by means of brushes (Thorsten M. buzug, 2008).

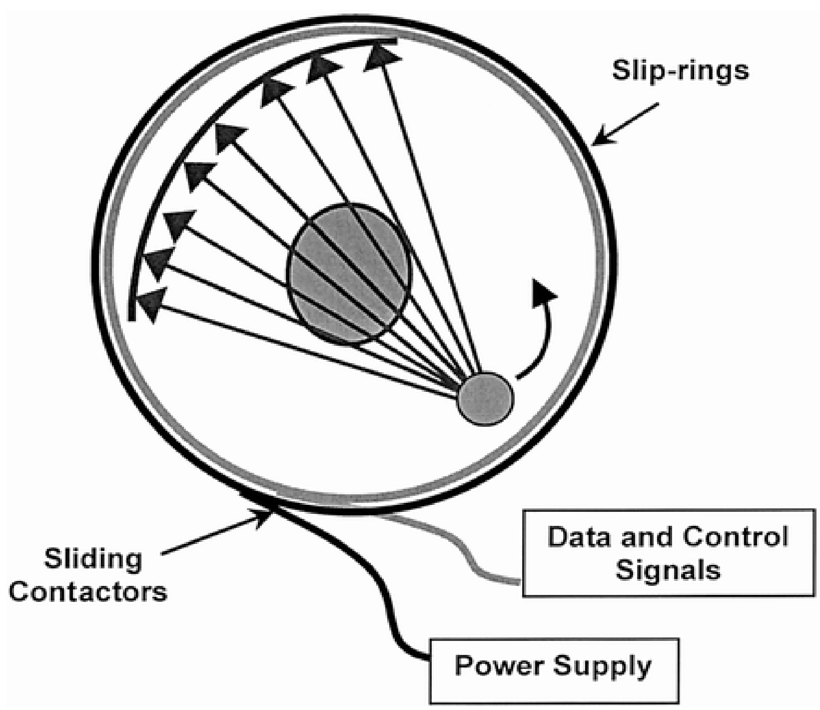


Figure (2.5) shows gantry component including slip-rings technology (Dr. Adel Montaser, 2003).

2. Pitch of image:

Pitch is relationship of table feed per rotation and x-ray collimators width. This Pitch independent of number of slices acquired and convey two essential imaging qualities. Firstly, increasing pitch results in widening of the slice beam profile and thus effect the image quality. Secondly, increasing the pitch lowers radiation dose.

3. Software image reconstruction algorithms:

Conventional CT used back projection techniques to reconstructs an image, and that may produce prominent blurring and dense shadowing. The data required for spiral CT image reconstruction is generated from projection acquired at superior and inferior anatomical location interpolation algorithms.

There are three common reconstruction algorithms:

1. 720o helical interpolation (360o linear interpolation)

2. 360o helical under-scanning.

3. Helical extrapolation (180o linear interpolation), (Thorsten M. buzug,2008).

2.3.2.3 The attenuation values:

The attenuation values are expressed on an arbitrary scale (Hounsfield Unit) with water density being zero, air density being 1000 units and bone density being plus 1000 unit. The range and the level of densities to be displayed can be selected by control on the computer. The range of densities visualized on a particular image is known as the window width (WW) and window level (WL).

2.3.2.4 CT Technique:

1. Patient position: supine with arms at chest or head level.

2. Volume of investigation: from dome of liver to the inferior border pubic symphysis.

3. Nominal slice thickness: 7-10 mm, 4-5 mm if small lesions are suspected.

4. Inter-slice distance\pitch: contiguous or a pitch=1.0 in screening investigation.

5. FOV: Adjusted to the largest abdominal diameter.

6. Gantry tilt: None.

7. X-ray tube voltage (KV): standard.

8. Tube currant and exposure time product (MAs): should be as low as consistent with required image quality.

9. Reconstruction algorithm: standard or soft tissue.

10. Window width: 150-600HU, 2000-3000 HU (bone if required).

11. Window level: 30-60 HU (enhanced examination), 0-30 HU (unenhanced examination), 400-600 HU (bone if required), (William R. Hendee et al, 2002).

2.3.2.5 CT artifact:

1. Patient motion artifact: motion can be voluntary or involuntary.

2. Metal artifact: metallic material such as prosthetic devices, dental filling, surgical clips and electrodes produce streak artifact on the image.

3. Beam hardening artifact: beam hardening is a phenomenon result from the increase of main energy of x-ray beam when it passes through object.

4. Stair-step artifact: this phenomenon appears as artifact on transverse images and as stair-steps, or strips (zebra artifact) on multiplanar reformation or 3D render images.

5. Partial volume artifact: Partial volume artifact arises when avoxel contains many types of tissue. It will produce CT number as an average of all types of tissue (Thorsten M. buzug, 2008).

2.3.2.6 Advantages of spiral CT:

1. Speed of imaging and patient throughput.

2. Elimination of respiratory misregistration.

3. Minimization of partial volume average effects.

4. Exact contiguity of images.

5. Optimized used and reduced volume of intravenous contrast medium.

6. Volume data acquisition and improved 3D imaging (Thorsten M. buzug, 2008).

2.3.2.7 Disadvantages of spiral CT:

1. Required a cooperative patient.

2. Required very precise timing of enhancement.

3. Vascular flow artifacts.

4. Helical reconstruction artifact.

5. Tube cooling and images reconstruction delays on asome machines (Thorsten M. buzug, 2008).

2.4 Previous studies:

Done by Passerotti C, et al (2003) for 50 patients suspected urolithiasis under wend CT and U/S .The clinical management was based on the result of each radiological test independently.

Compared to computerized tomography ultrasound had 76% sensitivity and 100% specificity. In 8 patients stone(s) seen on computerized tomography was not seen on ultrasound. The average size of missed stones was 2.3 mm. In 7 patients computerized tomography showed stones bilaterally but stone was seen on only 1 side on ultrasound. When evaluating the clinical impact, the ultrasound/computerized tomography discrepancy did not result in any significant change in clinical management except in 4 cases. In these cases ultrasound findings suggested that additional imaging was required and, thus, stone(s) in the distal ureter would have been identified on subsequent imaging.

Done by Omer S, et al (2004) for Twenty-nine infants aged between 2 to 94 months with clinical presentation suggestive of urolithiasis and a negative or indeterminate plain film were included in the study.

Presence of stones was confirmed in 23 of 29 patients (79%). Eight patients had single stone and the remaining 15 had multiple stones either in a single localization (single kidney or single ureter) or multiple localizations. Spiral CT detected 57 stones (45 renal and 12 ureteral). US detected 34 stones (59.6%) in 18 (78.2%) patients. US was able to localize 31 stones (68.8%) in 21 kidneys (75%), and 3 stones (25%) in 11 ureters (27.2%). Spiral CT is very effective in the diagnosis of pediatric urolithiasis. Spiral CT is more efficient than US in imaging pediatric patients with symptoms and signs of urolithiasis, when KUB is inconclusive.

Chapter three

Methodology

Chapter three

Methodology

3.1 Materials

3.1.1 Type of study

Is the study was cross sectional study.

3.1.2 Area of study

The study conducted in Khatoum state at alturky diagnostic center, Doctors clinic hospital and Al-Rebat University hospital.

3.1.3 Duration of study

The study conducted in duration from September 2016 to January 2017.

3.1.4 Population of study

People who examined by ultrasound, and spiral computed tomography and diagnosed as renal stone case

3.1.5 Study variables

The study variables include age and gender also presence, number, site and size of stone.

3.2 Methods

3.2.1 Subjects and clinical evaluations

Hundred patients with Urolithiasis were received from Al-Alturky diagnostic center, Doctors clinic, and Al-Rebat university hospital. Of them, 70 patients were male and 30 patients were female. The age variables was 14-24, 25-35, 36-45, 46-60, >60 years.

Diagnoses were made according to the Diagnostic and Statistical Manual of urology disorders in Sudan.

3.2.2 CT procedure

1.Patient position: supine with arms at chest or head level.

2.Volume of investigation: from dome of liver to the inferior border of the pubic symphysis.

3.Slice thickness: 4-5 mm.

4.FOV: Adjusted to the largest abdominal diameter.

5.Gantry tilt: None.

6.X-ray tube voltage: 120 Kv.

7.tube currant and exposure time product: 300 MAs

8.Window width: 150-600HU.

9.Window level: 30-60 HU.

3.2.3 U/S procedure

A 5MHz sector/linear transducer are used to scan the urinary tract. There is no specific preparation required for scanning the kidneys, only asked patient to drink 4 to 6 glasses of water for about an hour before the test to visualizing the lower ureters, vesico-ureteric junction, and the bladder. Besides fasting about 8Hr to avoid gas buildup in the intestines. The kidneys are scanned in the supine or lateral decubitus position. Using liver as window in right side and spleen in the left side. Moving probe intercostally from superior to inferior (longitudinal scan) and medial to lateral (transverse scan) to be assured you scan the entire kidney.

Then the probe is put in suprapubic area over the bladder and press to show the bladder clearly and scan in long and short axis (short axis is better to show wall thickness).

Ureter are not well visualized by u/s but when distended may see.

3.2.4 Equipment

Asia Hospital: GE 16 slice devise (model TSX-101A, Output 120kv – 600 mA) and U/S scans were acquired with ALOKA (model prosound, probe 3.54 MHz).

Medical Diagnostic Center: GE 16 slice devise.

Ahmed Gasim Hospital: helical CT scans were acquired with Chimadzu double slice devise (model Setion, Output 150kv – 500 mA) and U/S scans were acquired with TOSHIBA (model 2010, probe 3.54 MHz).

3.2.5 Data analysis

The data of the study was analyzed by SPSS statistical program.

3.2.6 Data presentation

Data displayed in the form of tables and figures.

3.2.7 Data storage

The data stored in CD.

3.2.8 Ethical consideration

All patient information was not throughout this study also The patient did not enter any unnecessary examination and had known that the data had taken for the research.

Chapter Four

Results

Chapter Four

Results

Table (4.1): Participants distribution with respect to gender:

Gender	Frequency	Percent
Male	68	68.0
Female	32	32.0
Total	**100**	**100.0**

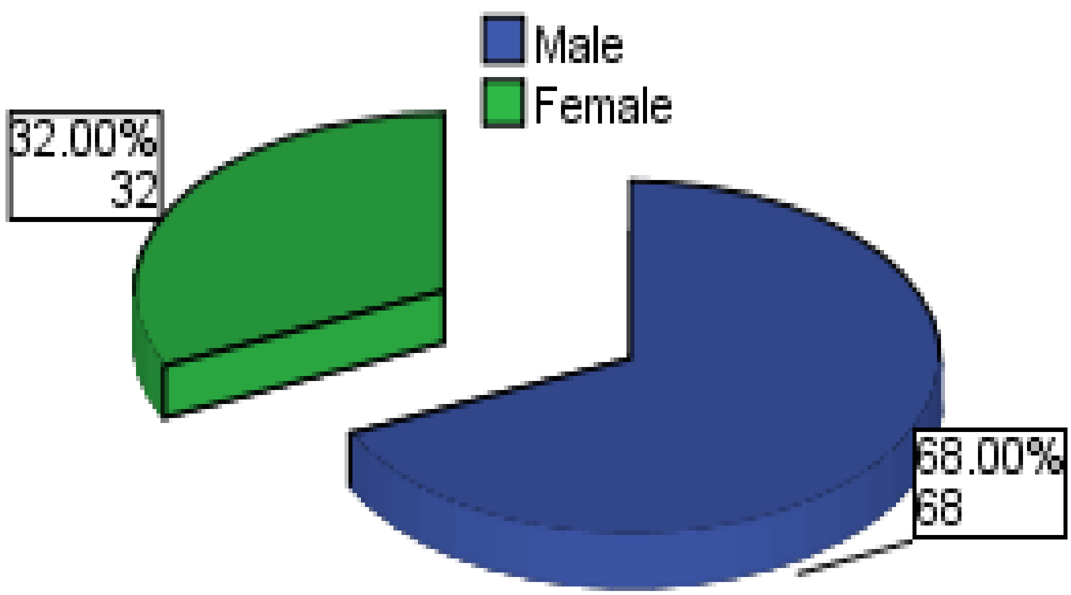


Figure (4.1): Participants distribution with respect to gender

Table (4.2): Participants distribution with respect to age:

Age	Frequency	Percent
Less than 10 years	1	1.0
10-20 years	10	10.0
21-30 years	18	18.0
31-40 years	24	24.0
41-50 years	16	16.0
51-60 years	17	17.0
More than 60 years	14	14.0
Total	**100**	**100.0**

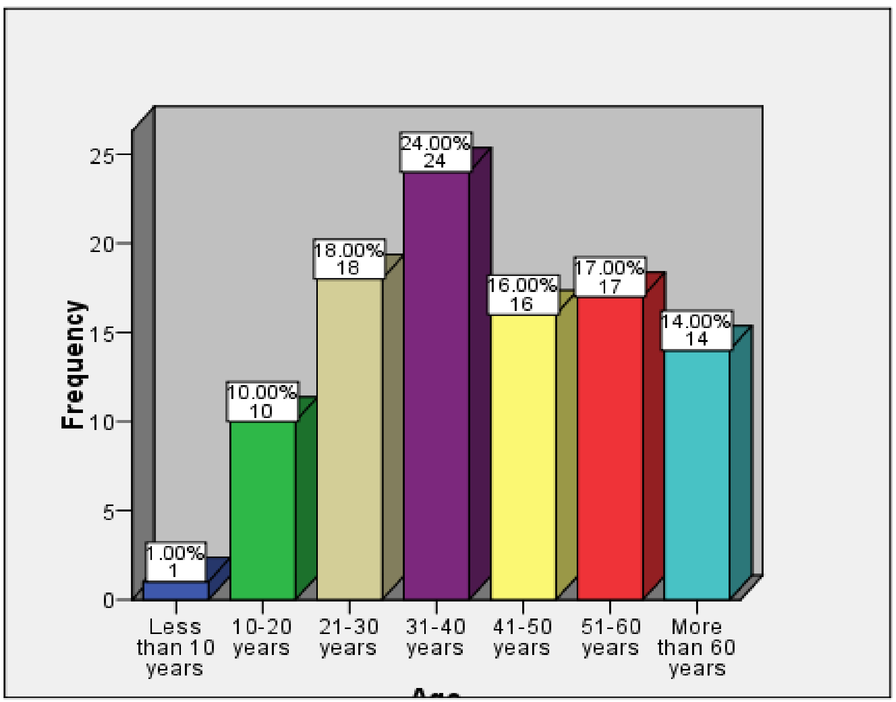


Figure (4.2): Participants distribution with respect to age

Table (4.3): Participants distribution with respect to presence:

Method	Frequency	Percent
CT	72	72.0
U/S and CT	28	28.0
Total	**100**	**100.0**

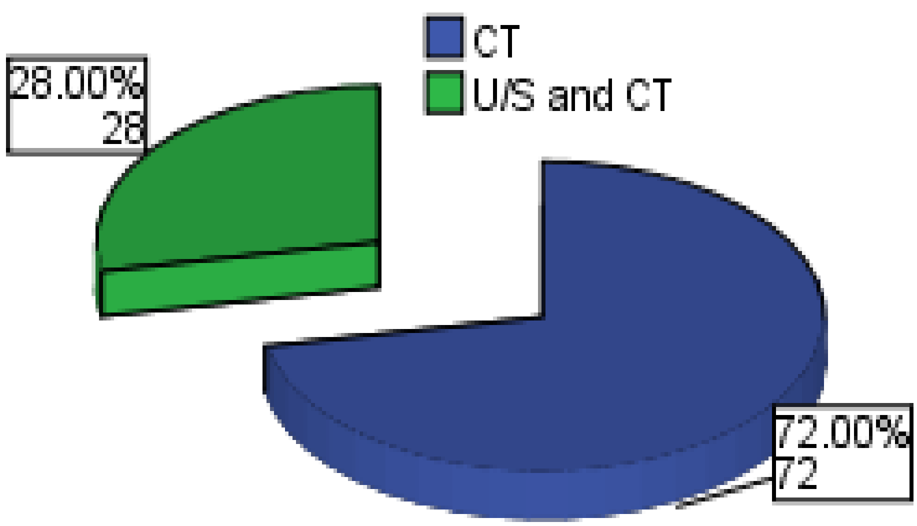


Figure (4.3): Participants distribution with respect to method

Table (4.4): Participants distribution with respect to urolithiasis site:

Site	**Frequency**	**Percent**
Bowel	3	3.0
Pelvic	10	10.0
Uretic	39	39.0
Renal	46	46.0
Bladder	2	2.0
Total	**100**	**100.0**

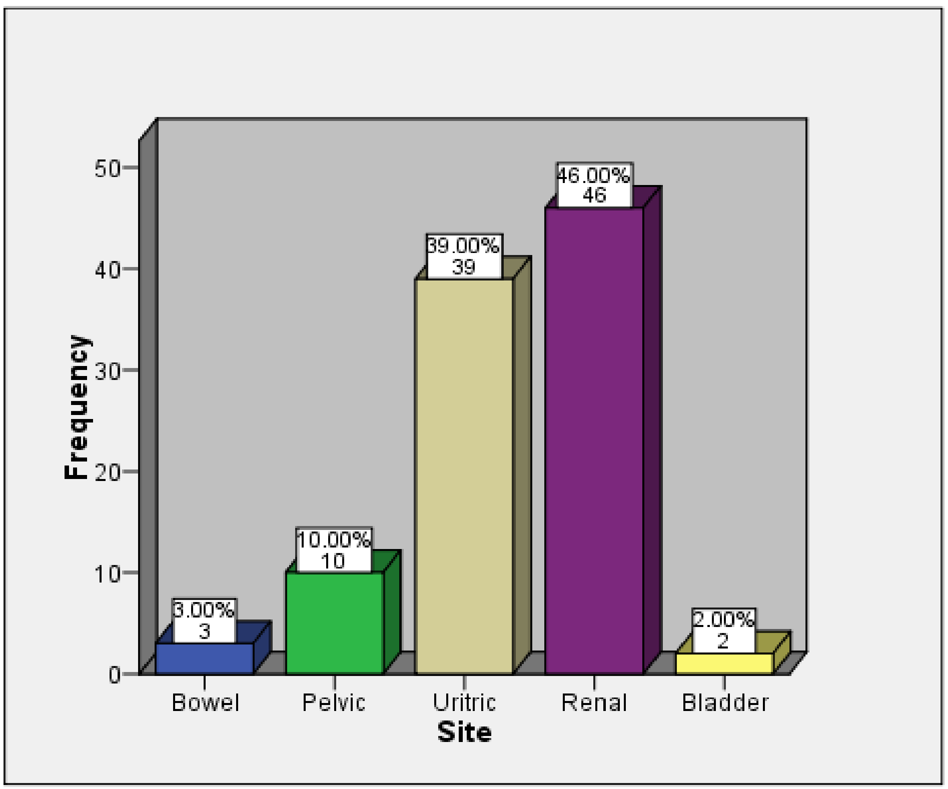


Figure (4.4): Participants distribution with respect to urolithiasis site

Table (4.5): Participants distribution with respect to urolithiasis size:

Size	Frequency	Percent
Less than 5 mm	22	22.0
5-10 mm	58	58.0
11-15 mm	14	14.0
More than 15 mm	6	6.0
Total	**100**	**100.0**

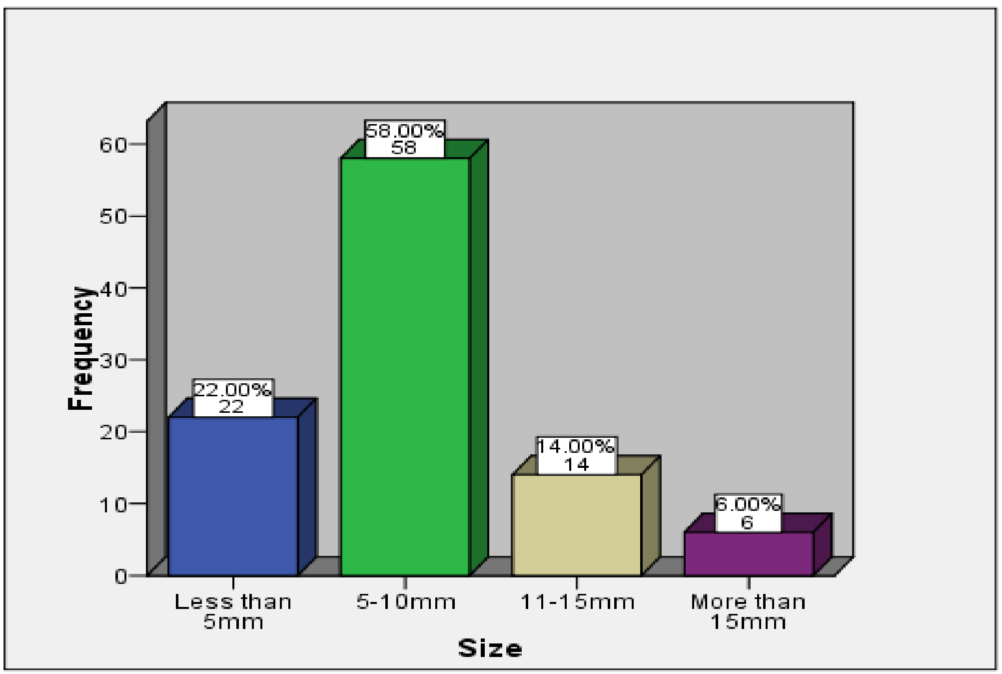


Figure (4.5): Participants distribution with respect to urolithiasis size

Table (4.6): Participants distribution with respect to urolithiasis density:

Density	Frequency	Percent
100-300 mm	9	9.0
300-500 mm	21	21.0
500-700 mm	17	17.0
700-900 mm	29	29.0
More than 900 mm	24	24.0
Total	**100**	**100.0**

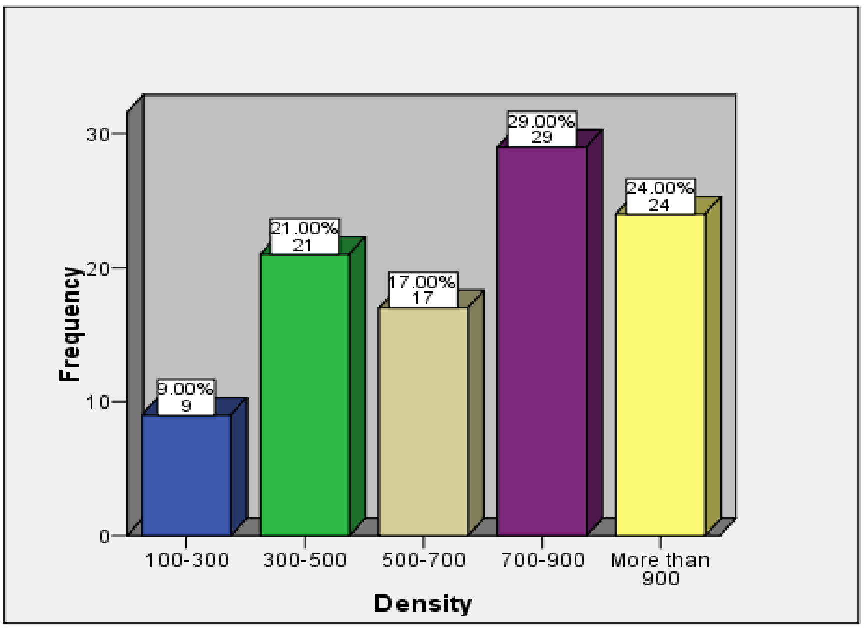


Figure (4.6): Participants distribution with respect to urolithiasis density

Table (4.7): Distribution participants' urolithiasis size with respect to method for CT and U/S:

		Method			
		CT		U/S and CT	
		Count	%	Count	%
CT urolithiasis size	Less than 5 mm	15	20.8%	7	25.0%
	5-10 mm	43	59.7%	15	53.6%
	11-15 mm	9	12.5%	5	17.9%
	More than 15 mm	5	6.9%	1	3.6%
U/S urolithiasis size	Less than 5 mm	0	0.0%	4	14.3%
	5-10 mm	0	0.0%	11	39.3%
	11-15 mm	0	0.0%	4	14.3%
	More than 15 mm	0	0.0%	9	32.1%

Table (4.8): Distribution participants' urolithiasis size with respect to method:

		Urolithiasis size				
Method		Less than 5 mm	5-10 mm	11-15 mm	More than 15 mm	**Total**
CT	Count	15	43	9	5	**72**
	%	20.8%	59.7%	12.5%	6.9%	**100.0%**
U/S and CT	Count	7	15	5	1	**28**
	%	25.0%	53.6%	17.9%	3.6%	**100.0%**
Total	**Count**	**22**	**58**	**14**	**6**	**100**
	%	**22.0%**	**58.0%**	**14.0%**	**6.0%**	**100.0%**
Chi-Square Tests						
		Value	df	Asymp. Sig. (2-sided)		
Likelihood Ratio		1.106	3	0.776		

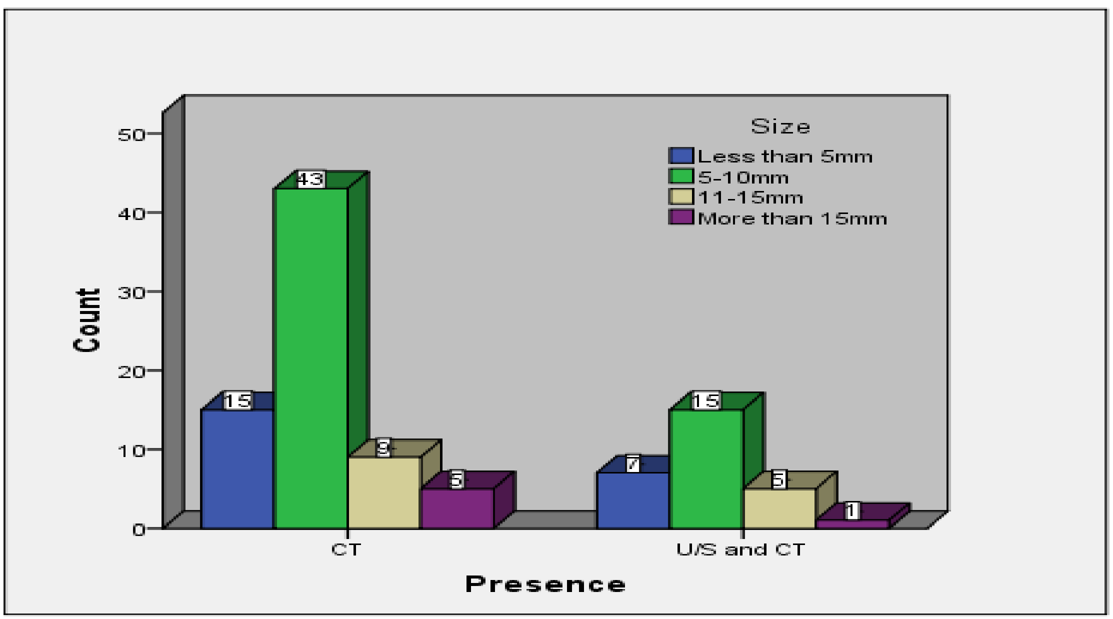


Figure (4.7): Distribution participants' urolithiasis size with respect to method

Table (4.9): Distribution participants, urolithiasis site with respect to method:

		Urolithiasis site					Total
Method		Bowel	Pelvic	Uretic	Renal	Bladder	**Total**
CT	Count	2	8	25	36	1	**72**
	%	2.8%	11.1%	34.7%	50.0%	1.4%	**100.0%**
U/S and CT	Count	1	2	14	10	1	**28**
	%	3.6%	7.1%	50.0%	35.7%	3.6%	**100.0%**
Total	**Count**	**3**	**10**	**39**	**46**	**2**	**100**
	%	**3.0%**	**10.0%**	**39.0%**	**46.0%**	**2.0%**	**100.0%**

Chi-Square Tests

	Value	df	Sig. (2-sided)
Likelihood Ratio	2.901	4	0.575

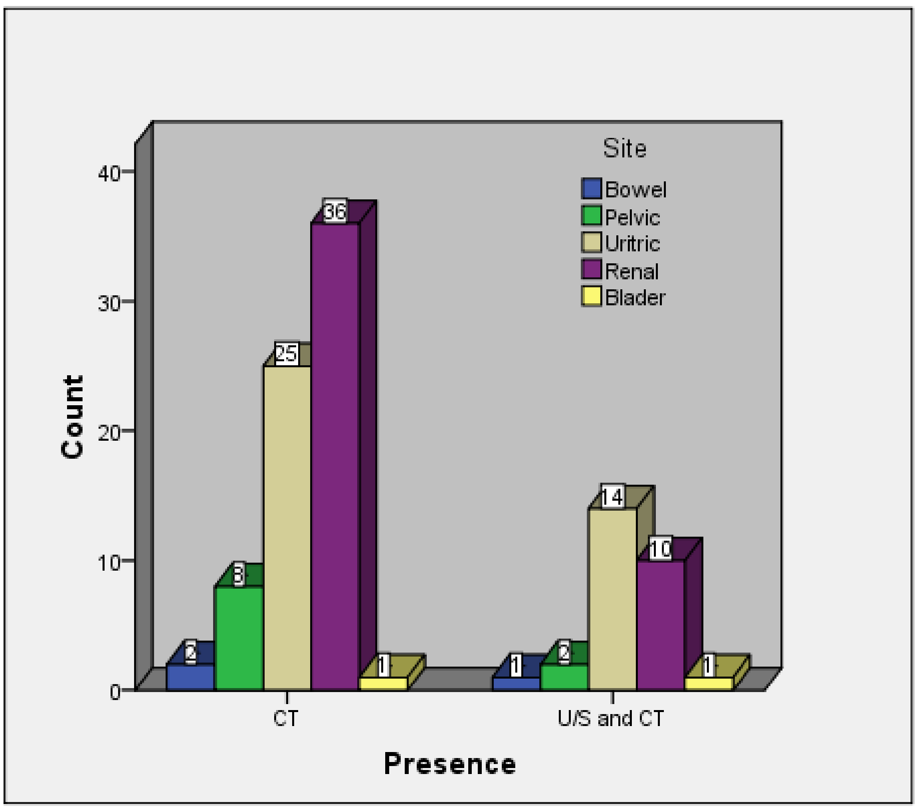


Figure (4.8): Distribution participants, urolithiasis site with respect to method

Table (4.10): Distribution participants, urolithiasis density with respect to method:

		Urolithiasis density					
Method		100-300	300-500	500-700	700-900	More than 900	**Total**
CT	Count	6	13	13	23	17	**72**
	%	8.3%	18.1%	18.1%	31.9%	23.6%	**100.0%**
U/S and CT	Count	3	8	4	6	7	**28**
	%	10.7%	28.6%	14.3%	21.4%	25.0%	**100.0%**
Total	**Count**	**9**	**21**	**17**	**29**	**24**	**100**
	%	**9.0%**	**21.0%**	**17.0%**	**29.0%**	**24.0%**	**100.0%**

Chi-Square Tests			
	Value	df	Sig. (2-sided)
Likelihood Ratio	2.129	4	0.712

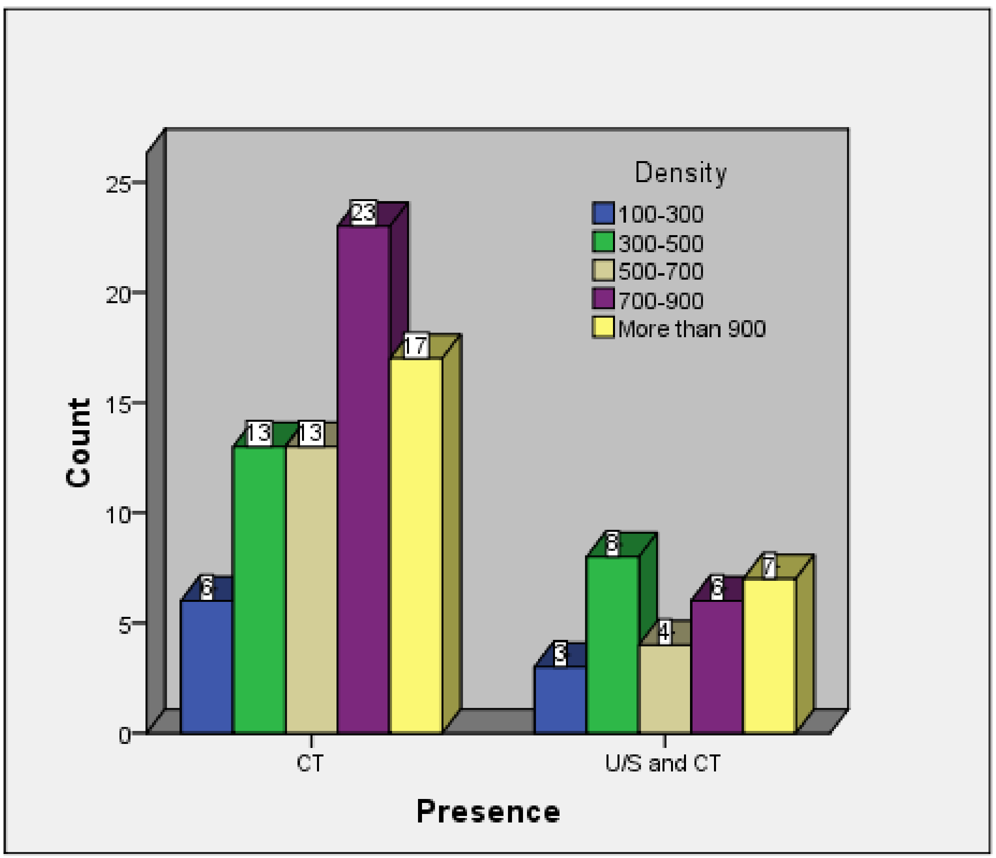


Figure (4.9): Distribution participants, urolithiasis density with respect to method

Chapter Five

Discussion, conclusion and recommendations

Chapter Five

Discussion, conclusion and recommendations

5.1 Discussion:

A sample of (100) patients most (68%) of were males (table 4.1) normally age distributed from 10 to 60 years old (85%) (table 4.2) was selected, then CT and U/S methods applied for urolithiasis diagnosis where (72%) of them received CT while (28%) received both CT and U/S (table 4.3).

The study found that the most urolithiases were renal (46%) and uretic (39%) (table 4.4) and its most common size was (5-10 mm) presented as (58%) and (less than 5 mm) as (22%) (table 4.5), while urolithiasis density was raged from 100 mm to more than 900 mm mostly more than 700 mm (53%, table 4.6).

The study found that urolithiasis size commonly was 5-10 mm (59.7%) for cases applied CT and (53.6%) for whom received both CT and U/S, urolithiasis size that which obtained by U/S was diversely distributed but mostly 5-10 mm (39.3%) and more than 15 mm (32.1%) compared to cases applied CT (table 4.7). While (table 4.8) urolithiasis size in association with diagnosis method was statistical insignificant different and it doesn't depend on the method to CT or U/S, P-value (Asymp. Sig.) for Chi-Square tests (Likelihood Ratio) was 0.776 which is greater than the test significant level (0.05) indicating that urolithiasis size was 5-10 mm for most (59.7%) of who applied CT, for (53.6%) of who applied both CT and U/S.

The study found (table 4.9) urolithiasis site in association with diagnosis method was statistical insignificant different and it doesn't depend on the method to CT or U/S, P-value (Asymp. Sig.) for Chi-Square tests (Likelihood Ratio) was 0.575 which is greater than the test significant level

(0.05), although, urolithiasis site was renal for most (50%) of who applied CT, while it was uretic for (50%) of who applied both CT and U/S.

The study found (table 4.10) urolithiasis density in association with diagnosis method was statistical insignificant different and it doesn't depend on the method to CT or U/S, P-value (Asymp. Sig.) for Chi-Square tests (Likelihood Ratio) was 0.712 which is greater than the test significant level (0.05), indicating that urolithiasis density is similarly distributed for who applied CT and who applied both CT and U/S.

5.2 Conclusion

The study concluded that the presence of urolithiasis in kidney is detected by both modalities in higher frequency than singular modality and the presence of urolithiasis in bladder is better detected by computer tomography.

The presence of urolithiasis in smallest valid of size (more than 5mm) is better detected by ultrasound, the presence of urolithiasis in veiled (less than 1cm- 3cm) is better detected by computed tomography and the presence of urolithiasis in veiled (more than 3cm- 5 cm) is better detected by computed tomography.

5.3 Recommendations

1. The study recommended that all people to drink plenty of water to prevent dehydration especially who work under the sun light.

2. The study recommended advices all people who exceed 49 years to take care about their general health to provide early detection of such disease.

3. In suspicion of number of stones we must do both modalities to make sure.

4. The study recommended that if the stone is suggested in kidney the U/S should be chosen and if it suggested in ureter or bladder the CT should be chosen.

5. For small size stones I recommended that the patient undergo U/S examination.

References:

Albert A. Moss et al, 1992, Computed Tomography of the body with magnetic resonance imaging, 2nd edition, sunders company, Philadelphia, USA.

Dr. Adel Montaser, 2003, Diseases of Liver, Biliry system Pancreas G.Marchal et al, 2005, Multidetector Raw Computed Tomography Scanning and Contrast Protocols, 1st edition Springer Milan Berlin Heidelberg,New York.

Henry Grey, Warren H Lewis, 2000, Grey Anatomy of the Human Body,

20th Edition, and Philadelphia: Lea&Febiger 1918; New York: Bartleby.com Hsieh, Jiang.2009. Computed tomography: principles, design, artifacts, and recent advances, 2nd edition, Bellingham, Washington.

Jain E Gillespie, T.J. Thompson, 1983, Gastroentrology, An integrated course,3nd edition,Churchilllivingstone.

Jamescd.mace, Nina Kowalczyk 2001, Radiographic phathology for technologists

Jerrold T. Bushberg et al, 2002, the essential physics of medical imaging,

2nd edition, Philadelphia, USA.

K. Subburaj, 2011, CT scanning technique and application, 1st Edition, janezatrdine,Rijeka, Croatia.

R.bruening et al, 2006, protocols for multislice CT,, 2nd edition, springer,

verlag berlin hiedelberg, Germany.

Ramsay Vallance et al, 1999, an atlas of Diagnostic radiology in gastroenterology,1st edition, oxford,united kingdom.

Thorsten M. Buzug,2008, Computed Tomography from Photon Statistics to Modern Cone-Beam CT,1st edition, Springer- Verlag Berlin Heidelberg, Germany.

William R. Hendee et al, 2002, medical imaging phsics, 4th Edition, Wiley-Liss, Inc., New York.

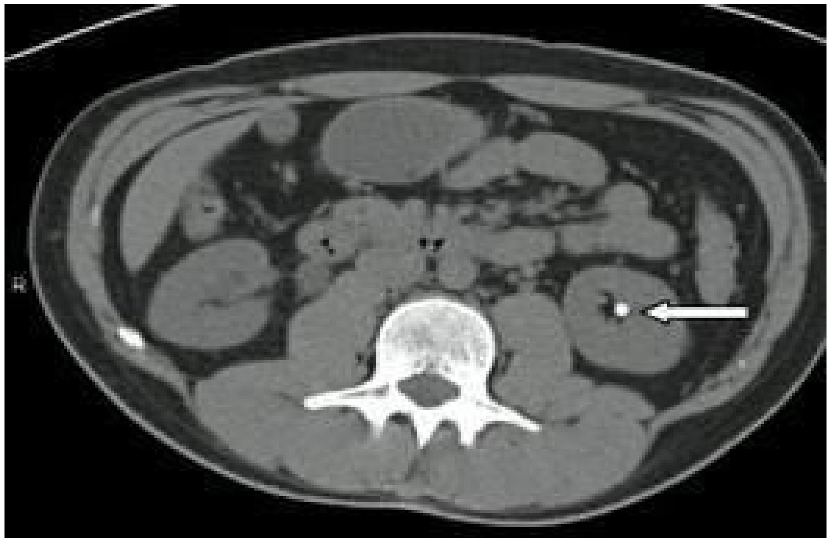
Appendices

Appendix 1

Data Sheet

Gender	Age	CT	Sit	Size	Density	US

Appendix 2



Axial CT to demonstrate renal stone Coronal CT to demonstrate ureter stone

Coronal CT to demonstrate ureter stone

Axial CT to demonstrate bladder stone

Ultrasound to show kidney stone