كلية الدراسات العليا

Sudan University for Science and Technology
College of Graduate Studies

Classification of Renal Stone Types In Ultrasound Images Using Texture Analysis

تصنيف أنواع حصاوي الكلي في صور الموجات فوق الصوتية

بإستخدام تحليل النسيج

A thesis submitted for fulfillment of the requirements of PhD degree in Medical Physics

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بسم الله الرحمن الرحيم

الآيـــــة

قال تعالى:-

(وقل ربى أدخلنى مدخل صدق وأخرجني مخرج صدق وأجعل لي من لدنك سلطاناً نصيراً).

صدق الله العظيم

سورة الإسراء الآية(80)

Dedication

To the soul of my parents

To all- sweethearts

My husband

And my fellow brother

To each student

MY teachers

And

MY FRIEND

Acknowledgment

This thesis would not have been possible without the support of many people. I wissh to express my gratitude to my supervisor ***prof.Mohmmed Elfadil Mohmed*** *who was abundantly helpful and offered invaluable assistance, support and guidance. Deepest gratitude are also due to the members of the supervisory committee,* ***Dr. Khaleid Mohmedin Ali*** *and* ***Dr. Abdelrahim and Dr.Randa*** *without their knowledge and assistance this study would not have been successful.*

Special thanks also to all my graduate friends for sharing the literature and invaluable assistance. Not forgetting to my best friends who always been there.

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I wish to express my love and gratitude to my beloved family.

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List of Abbreviations

U/S	Ultra Sound
ESWL	Extracorporeal Shock wave lithotripsy
KUB	Kidney Ureter & Bladder
CT	Computed Tomography
NIDDK	National Institute of Diabetes and Digestive and Kidney Diseases
DH	Daman Hospital
UK	University of Kordufan
EC	Elsalama Centre
TLD	Thermoluminescent dosimeters
ESRD	End Stage Renal Disease
IDL	Interactive Data Language

Abstract

This analytical cross-sectional study aim to classify renal stone type using Ultrasonography. The density of renal stone usually determined the type of treatment where the stone density ≤ 1000 HU (type I) the patient need Extracorporeal Shock wave lithotripsy and if the stone density ≥ 1000HU patient need surgery and the density can be obtained through Computed Tomography. The general objective of this study was to reduce the radiation dose to patient by using Ultrasonography, Computed Tomography image cost and time. The data was collected using data sheets from three centers (university of kordufan diagnostic centre, Eldaman hospital and Elsalama clinic centre), The study has been carried out during the period from April 2017 up to October 2019. The patient data were statically analyzed by SPSS and M.S Excel. The stone density was measured to 90 patients' 68 males (75.6%) and 12 females (13.3%) the mean stone density was found to be 808HU, the mean of stone length was found 1.53cm, the mean stone width was found 1.08cm, while the mean age of patient was 49 years and the mean stone area was 2.24cm2. 61 patients stone density type I and 29 patient type II. then the some data were collected from those patient using ultrasound images and by analyzing images by IDL in order to classify the stone into type I and II using linear demonstrate analysis and texture feature as input data, the result of classification showed that the overall accuracy was 96.7% and for stone type one was 100% and type two was 91.7%, from this program the consultant could chose the best decision for the patient.

الملخص

هذه دراسة تحليليه هُدفت لتصنيف أنواع حصاوي الكلي بإستخدام التصوير عبر جهاز الموجات فوق الصوتيه، كثاقة حصاوي الكلي عادة تحدد نوعية العلاج إذا كانت كثافة الحصوة $\geq$ HU 1000 (النوع الأول) المريض يحتاج إلي عملية تفتيت حصوه وإذا كانت كثافة الحصوة $\leq$ HU 1000 (النوع الثاني) المريض يحتاج إلي عملية جراحية. تحدد كثافة الحصوة عبر جهاز الأشعة المقطعية ، والهدف من هذه الدراسة تقليل جرعة الإشعاع للمريض، توفير تكلفة صورة الأشعه المقطعية، وتوفير الزمن.

جٌمعت بيانات المرضي في إستمارات من ثلاث مراكز (مركز جامعة كردفان التشخيصي، مستشفي الضمان، عيادة السلامه) في الفترة من أبريل 2017م وحتي إكتوبر 2019م تم تحليل بيانات المرضي بالتحليل الإحصائي عبر SPSS و M.S excel.

قًيست كثافة الحصوة لعدد 90 مريض 68 ذكور 75.6% و12 إناث 13.3% وجد متوسط كثافة الحصوة HU808 ومتوسط طول الحصاوى 1.53سم' ومتوسط عرض الحصاوى 1.08سم، ومتوسط أعمار المرضي 49 سنه، متوسط مساحة الحصاوى2.24سم^2. 61 مريض كثافة حصاويهم من النوع الأول و29 مريض متوسط كثافة حصاويهم من النوع الثاني، وبعد تحليل صور الموجات فوق الصوتية عبر برنامج IDL وتحليل الأنماط صًنفت الحصاوى إلي النوع الأول والنوع الثاني بإستخدام تحليل التظاهر الخطي أدخلت البيانات وعرضت نتائج التصنيف بدقه 96.6% ، للحصاوى من النوع الأول كانت 100% ومن النوع الثاني كانت 91.7%، ومن هذا البرنامج يمكن للطبيب ان يختار القرار المناسب للعلاج.

Chapter One

Introduction

1.1Introduction:-

Kidney diseases are on rise throughout the world and majority people with kidney disease do not notice the disease as it damages the organ slowly before showing symptoms. The increasing number of patients with kidney diseases leads to a high demand of early detection and prevention of kidney diseases. It is well known that ultrasound (U\S) can be used as an initial evaluation to estimate kidney size and position, and help to diagnose structural abnormalities as well as presence of cysts and stones' the Ultra Sound Machine transmits high- frequency (1-5 megahertz), which reflect off body structures. A computer receives the waves and uses them to create a picture. Unlike with an x-ray or CT scan, this test does not use ionizing radiation (wocester et al 2008).

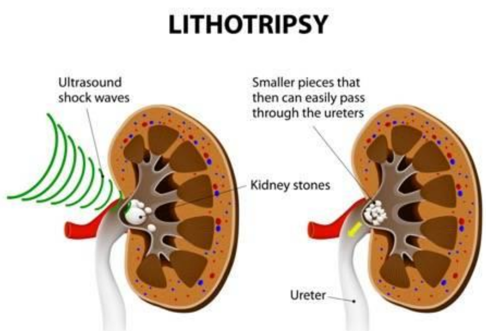
However, diagnosis of kidney diseases and abnormalities using U/S demands decision from experts as US images suffer from speckle noise. Speckle has variation of gray level intensities. Therefore, to enhance quality of these images, some image processing techniques are usually applied for better understanding of hidden information as well as for extracting some parameters or features that will be useful for diagnosis of the images. Current estimates are that 30 million (1 in 11) Americans will experience a kidney stone within their lifetime, and up to 50% of new stone formers will have a recurrence, within as early as 5 years . The data suggest the incidence of kidney stones will continue to grow with our increasing obesity and diabetes rate, and even climate change.

When dietary minerals in the urine become supersaturated, crystals of Urinary stones are formed. Stones almost always start in the kidneys which may cause problems or may not be noticed until they move into the urethra. Once stones pass down the urethra into the bladder, they usually then are passed with the urine, but sometimes they can get into the bladder and grow larger there. The most common symptom of kidney stones is pain in upper back. When the pain is severe there is possibility of getting nausea as well. There can be blood in the urine and also a urinary tract infection. Stones are diagnosed with CT scans, X-rays, or ultrasound. A kidney stone may not cause symptoms until they move within your kidney or until it passes into urethra, the tube connecting the kidney and bladder. Severe pain in the side and back, below the ribs pain may spread to lower abdomen and Pain that comes in waves and fluctuates in intensity, Pain on urination, Cloudy or foul-smelling urine, Nausea and vomiting, Persistent need to urinate, Urinating more often than usual Fever and chills if an infection is present (Sidney S.lee chair - 2000). Shockwave lithotripsy (SWL) is a noninvasive procedure for breaking up kidney stones with high-energy shock waves. SWL is the least invasive and least risky approach to stone treatment. (SWL) is the most common type of treatment for removing kidney stones. Usually, stones that form in the kidneys are small enough to pass through the urinary tract and are excreted (passed) along with urine. Whether kidney stones can be successfully treated with SWL depends on the size of the stones and their number, position, and type. The hardness and depth of the stone is measured on a CT scan before surgery to predict the likelihood of success. The procedure produces the best results when the kidney stones are no larger than 1.5 centimeters in diameter. The stones must be visible with an X-ray monitor during the treatment. SWL might not be suitable for patients who are obese or on blood thinners (wocester et al 2008).

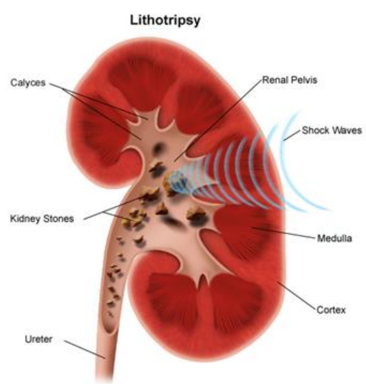
1.2 (ESWL) for Kidney Stones treatment:-

(ESWL) uses shock waves to break a kidney stone into small pieces that can more easily travel through the urinary tract and pass from the body. Figure (1.1) (Sidney S.lee chair). Patient lie on a water-filled cushion and the surgeon uses X-rays test to precisely locate the stone. High-energy sound waves pass through your body without injuring it and break the stone into small pieces Figure (1.2) (James hingnau – 2003). These small pieces move through the urinary tract and out of the body more easily than a large stone. The process takes about an hour. You may receive sedatives or local anesthesia. Your surgeon may use a stent if you have a large stone. A stent is a small, short tube of flexible plastic mesh that holds the ureter open. This helps the small stone pieces to pass without blocking the ureter. ESWL is usually an outpatient procedure. You go home after the treatment and do not have to spend a night in the hospital. After ESWL, stone fragments usually pass in the urine for a few days and cause mild pain. If you have a larger stone, you may need more ESWL or other treatments (wocester et al 2008). ESWL may be used on a person who has a kidney stone that is causing pain or blocking the urine flow. Stones that are between (0.4 cm and 2 cm) in diameter are most likely to be treated with ESWL. The ESWL may work best for kidney stones in the kidney or in the part of the ureter close to the kidney. Your surgeon may try to push the stone back into the kidney with a small instrument (ureteroscope) and then use ESWL, and is usually not used if you are pregnant the sound waves and X-rays may be harmful to the fetus. ESWL does not replace the need for the preventive treatment of kidney stones, such as drinking enough fluids so that you don't get dehydrated.

ESWL does not successfully treat **cystine** kidney stones (hard stone), these stones do not break up easily, and is a safe procedure and may be used on children and on individuals with only one working kidney. ESWL should not be used if you have pacemaker unless a cardiologist has determined it is safe (Lee J Y et al 2001).



(Figure 1.1) Renal Stone



(Figure 1.2) lithotripsy principle

1.3 Kidney Ultrasound: -

A kidney ultrasound is a noninvasive diagnostic exam that produces images, which are used to assess the size, shape, and location of the kidneys. Ultrasound may also be used to assess blood flow to the kidneys. Ultrasound uses a transducer that sends out ultrasound waves at a frequency too high to be heard. The ultrasound transducer is placed on the skin, and move through the body to the organs and structures within. The sound waves bounce off the organs like an echo and return to the transducer. The transducer processes the reflected waves, which are then converted by a computer into an image of the organs or tissues being examined (Lee J Y et al 2001). The sound waves travel at different speeds depending on the type of tissue encountered - fastest through bone tissue and slowest through air. The speed at which the sound waves are returned to the transducer, as well as how much of the sound wave returns, is translated by the transducer as different types of tissue. An ultrasound gel is placed on the transducer and the skin to allow for smooth movement of the transducer over the skin and to eliminate air between the skin and the transducer for the best sound conduction. Ultrasound may be safely used during pregnancy or in the presence of allergies to contrast dye, because no radiation or contrast dyes are used figure (1.3) (Emilio Quaia -2014).

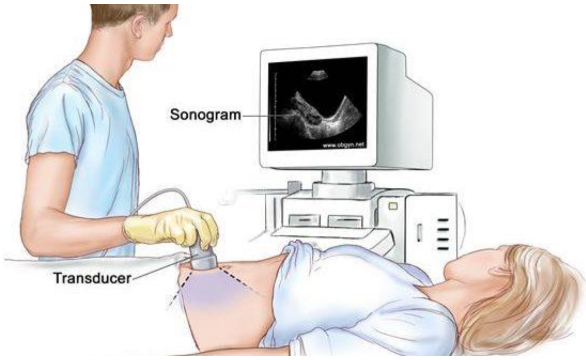


Figure (1.3) U/S scan

Other related procedures that may be performed to evaluate the kidneys include X-ray, computed tomography (CT scan), kidney scan, Figure (1.4). A kidney ultrasound may be used to assess the size, location, and shape of the kidneys and related structures, such as the ureters and bladder. Ultrasound can detect cysts, tumors, abscesses, obstructions, fluid collection, and infection within or around the kidneys. Calculi (stones) of the kidneys and ureters may be detected by ultrasound. A kidney ultrasound may be performed to assist in placement of needles used to biopsy (obtain a tissue sample) the kidneys, to drain fluid from a cyst or abscess, or to place a drainage tube. This procedure may also be used to determine blood flow to the kidneys through the renal arteries and veins.Kidney ultrasound may be used after a kidney transplant to evaluate the transplanted kidney (Lee J Y et al 2001).

Figure (1.4) U/S Renal image

1.4 CT scan (KUB):-

CT scan is a noninvasive diagnostic imaging procedure that uses a combination of X-rays and computer technology to produce horizontal, or axial, images (often called slices) of the body. A CT scan shows detailed images of any part of the body, including the bones, muscles, fat, and organs. CT scans are more detailed than standard X-rays. In standard X-rays, a beam of energy is aimed at the body part being studied. A plate behind the body part captures the variations of the energy beam after it passes through skin, bone, muscle, and other tissue. While much information can be obtained from a standard X-ray, a lot of detail about internal organs and other structures is not available.

In CT the X-ray beam moves in a circle around the body. This allows many different views of the same organ or structure. The X-ray information is sent to a computer that interprets the X-ray data and displays it in a two-dimensional (2D) form on a monitor. Figure (1.5) (maarten W.Taal, Glenn M.chertow, Philip A.Marsobm -2011)

CT scans may be done with or without "contrast." Contrast refers to a substance taken by mouth or injected into an intravenous (IV) line that causes the particular organ or tissue under study to be seen more clearly. Contrast examinations may require you to fast for a certain period of time before the procedure. Your doctor will notify you of this prior to the procedure (sheafor D H et al 2000). CT scans of the kidneys can provide more detailed information about the kidneys than standard kidney, ureter, and bladder (KUB) X-rays , thus providing more information related to injuries or diseases of the kidneys. CT scans of the kidneys are useful in the examination of one or both of the kidneys to detect conditions such as tumors or other lesions, obstructive conditions, such as kidney stones, congenital anomalies, polycystic kidney disease, accumulation of fluid around the kidneys, and the location of abscesses. Figure (1.6), Other related procedures that may be used to diagnose kidney problems include KUB X-rays, kidney biopsy, kidney scan, kidney ultrasound, renal angiogram, and renal venogram. CT scans of the kidney may be used to evaluate the retroperitoneum (the back portion of the abdomen behind the peritoneal membrane). CT scans of the kidney may be used to assist in needle placement in kidney biopsies After the removal of a kidney, CT scans may be used to locate abnormal masses in the empty space where the kidney once was. CT scans of the kidneys may be performed after kidney transplants to evaluate the size and location of the new kidney in relation to the bladder. There may be other reasons for your doctor to recommend a CT scan of the kidney. The risks of a CT scan you may want to ask your doctor about the amount of radiation used during the CT procedure and the risks related to your situation. It is a good idea to keep a record of your past history of radiation exposure, such as previous CT scans and other types of X-rays, so that you can inform your doctor. Risks associated with radiation exposure may be related to the cumulative number of X-ray examinations and/or treatments over a long period of time. If you are pregnant or suspect that you may be pregnant, you should notify your doctor. Radiation exposure during pregnancy may lead to birth defects. If contrast media is used, there is a risk for allergic reaction to the media. Patients who are allergic to or sensitive to medications should notify their doctor. You will need to let your doctor know if you have ever had a reaction to any contrast media, and/or any kidney problems. A reported seafood allergy is not considered to be a contraindication for iodinated contrast (William E, Nancy M ,Major -2006). Patients with kidney failure or other kidney problems should notify their doctor. In some cases, the contrast media can cause kidney failure, especially in patients with underlying kidney problems or dehydration. Patients taking the diabetes medication metformin (Glucophage), or its derivatives, who receive contrast, are at increased risk of developing a condition called metabolic acidosis, or an unsafe change in blood pH, and the drug may be halted for 48 hours after the procedure.

There is a small chance of contrast material leakage from the IV line, which may cause swell stinging pain, or skin damage at the IV site. There may be other risks depending on your specific medical condition. Be sure to discuss any concerns with your doctor prior to the procedure. Certain factors or conditions may interfere with the accuracy of a CT scan of the kidney. CT scans may be performed on an outpatient basis or as part of your stay in a hospital. Procedures may vary depending on your condition and your physician's practices.

Figure (1.5) CT scan machine

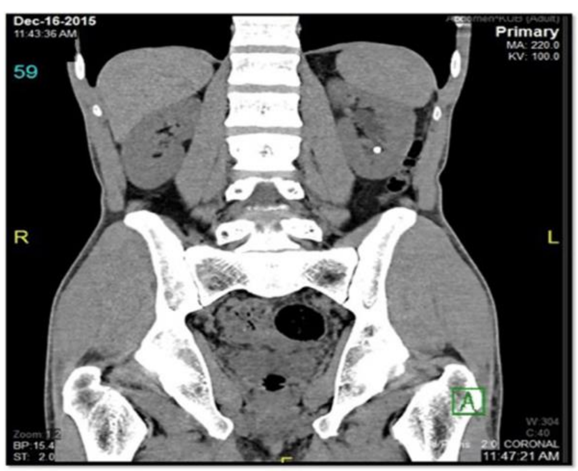


Figure (1.6) CT scan KUB

1.4.1 What happens after a CT scan:-

If contrast media was used during your procedure, you may be monitored for a period of time for any side effects or reactions to the contrast media, such as itching, swelling, rash, or difficulty breathing. If you notice any pain, redness, and/or swelling at the IV site after you return home following your procedure, you should notify your doctor as this could indicate an infection or other type of reaction. Otherwise, there is no special type of care required after a CT scan of the kidney. You may resume your usual diet and activities unless your doctor advises you differently. Your doctor may give you additional or alternate instructions after the procedure, depending on your particular situation (sheafor D H et al 2000).

1.5 Problem of Study:

The density of renal stone usually determined the type of treatment and the density can be obtained through CT scan which is not available allows the CT KUB radiation dose and height cost, there for if density of the stone determined by U/S a lot of problem can be Solved.

1.6 Objective of the study:-

1.6.1 General objective:

To classify the density of renal Stone using U/S and CT images.

1.6.2 Specific objectives:

- To obtain patient age, Gender.
- To measure the Stone length, width and size.
- To calculate the mean stone density using U/S image.
- To correlate CT stone density with U/S Stone density.
- To estimate renal stone density using U/S image.

- To classify stone as type one and two (<1000 and > 1000) using linear discriminate analysis.

1.7 Significance of the study: -

To reduce the radiation dose and CT cost to lithotripsy patients

1.8Thesis outline:

The following thesis will be consisting of five chapters. *Chapter one* deals with introduction, problem, objectives and the thesis of study. *Chapter two* highlights the literature review. Chapter three contains the features of the machine used in this study and methods. Chapter four shows the result of data collection. Chapter five shows the discussion, conclusion, recommendation and references.

Chapter two

Theoretical background

2.1 Urinary System:-

The urinary system consists of the kidneys, ureters, bladder, and urethra. The kidneys form the urine and account for the other functions attributed to the urinary system. The ureters carry the urine away from kidneys to the bladder, which is a temporary reservoir for the urine. The urethra is a tubular structure that carries the urine from the urinary bladder to the outside figure (2.1) (Stephanie Watson - 2004).

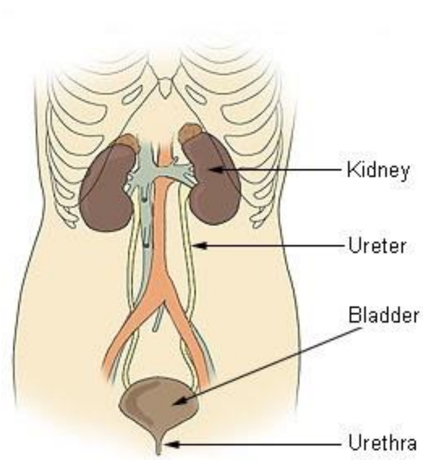


Figure (2.1) urinary System

2.1.1 The kidney:-

The kidneys are a pair of bean-shaped organs on either side of your spine, below your ribs and behind your belly. Each kidney is about 4 or 5 inches long, roughly the size of a large fist. The kidneys' job is to filter your blood. They remove wastes, control the body's fluid balance, and keep the right levels of electrolytes. All of the blood in your body passes through them several times a day (McConell et al 1994).

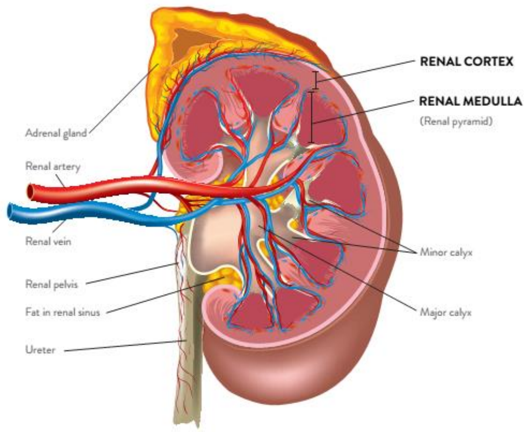


Figure (2.2) internal anatomy of the kidneys

2.1.2 Anatomy and physiology of kidney:-

A kidney contains over 1 million functioning units called nephrons. Each nephron is composed of a glomerulus and tubule figure (2.3). The glomerulus acts to filter the blood free of cells and large proteins, producing an ultrafiltrate composed of the other smaller circulating elements. The ultrafiltrate enters the tubule, which is highly specialized at various segments, to produce the final urine by removing substances from the tubular fluid (reabsorption) or adding substances to the tubular fluid (secretion). Filtration, reabsorption, and secretion keep the organism in balance in terms of water, minerals, electrolytes, and hydrogen ion concentration and eliminate the toxic substances produced by the body. The major known hormonal functions of the kidney influence blood pressure, calcium metabolism, and red blood cell production (Sakhaee et al 2002).

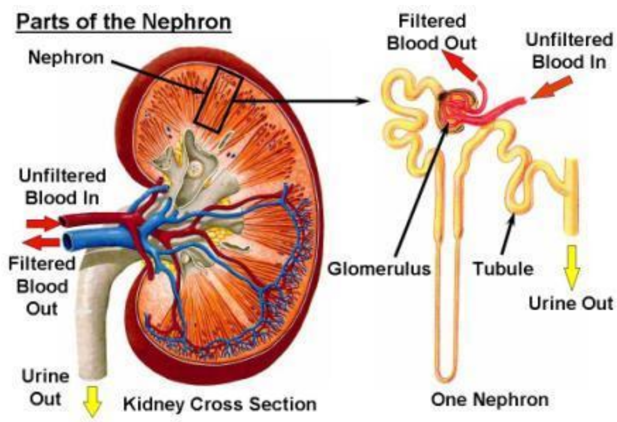


Figure (2.3) Kidney structure

2.1.3 How do the kidneys work:-

The body takes nutrients from food and converts them to energy. After the body has taken the food that it needs, waste products are left behind in the bowel and in the blood, the kidneys and urinary system keep chemicals, such as potassium and sodium, and water in balance, and remove a type of waste, called urea, from the blood. Urea is produced when foods containing protein, such as meat, poultry, and certain vegetables, are broken down in the body. Urea is carried in the bloodstream to the kidneys.

Two kidneys, a pair of purplish-brown organs, are located below the ribs toward the middle of the back. Their function is to:

-Remove liquid waste from the blood in the form of urine.

- Keep a stable balance of salts and other substances in the blood.

- Produce erythropoietin, a hormone that aids the formation of red blood cells.

-Regulate.blood.Pressure.

-The kidneys remove urea from the blood through tiny filtering units called nephrons. Each nephron consists of a ball formed of small blood capillaries, called a glomerulus, and a small tube called a renal tubule.

Urea, together with water and other waste substances, forms the urine as it passes through the nephrons and down the renal tubules of the kidney (Sakhaee et al 2002).

2.1.4 Pathology of kidney:-

Pyelonephritis (infection of kidney pelvis): Bacteria may infect the kidney, usually causing back pain and fever. A spread of bacteria from an untreated bladder infection is the most common cause of pyelonephritis.

Glomerulonephritis: An overactive immune system may attack the kidney, causing inflammation and some damage. Blood and protein in the urine are common problems that occur with glomerulonephritis. It can also result in kidney failure (Worcester E M et al 2008).

Kidney stones (nephrolithiasis): Minerals in urine form crystals (stones), which may grow large enough to block urine flow. It's considered one of the most painful conditions. Most kidney stones pass on their own, but some are too large and need to be treated.

2.1.5 The kidney stones: -

Kidney stones, or renal calculi, are solid masses made of crystals. Kidney stones usually originate in your kidneys. However, they can develop anywhere along your urinary tract, which consists of these parts:
kidneys, ureters, bladder and urethra.

Kidney stones are one of the most painful medical conditions. The causes of kidney stones vary according to the type of stone (Worcester E M et al2008).

2.1.6 Types of renal stones: -

Kidney stones are hard deposits made up of minerals and salts or are made up of crystals which form inside the kidneys. Stones are formed when urine becomes concentrated, allows minerals to crystallize and stick together, we know it causes lots of pain or we can say it is the most painful medical condition, Severe pain that is caused due to kidney stone is called renal colic. Pain can occur on one side of your back or abdomen. These days it is very common disease and mostly found in an individual. Different types of Kidney stones figure (2.4) from (Oct31,2017,Shikha Golal).

1. **Calcium Stones**: These stones are commonly found. They are made up of calcium oxalate, phosphate or maleate. They tend to form when urine is acidic i.e. having low pH. Some oxalate is produced by the body in urine and also by the liver. Diet plays a crucial role in the formation of stone. Diet consisting of less oxalate-rich foods can reduce the risk of developing this type of calcium stone. Oxalate is found in many vegetables like potato chips, spinach, fruits, nuts, chocolate etc. Even high dose of vitamin D, intestinal bypass surgery, metabolic disorder also increases the concentration of calcium oxalate in urine. Calcium stone is also formed in the form of phosphate. In some metabolic conditions this type of stone is found like renal tubular acidosis.

2. **Uric acid Stones**: These stones are commonly found in men than in women. People those who have gout or went through chemotherapy have uric acid stones. These stones are formed in those people who drink less fluid, who eat high protein diet, whose urine is most acidic. Some genetic factors also increase the risk of uric acid stones.

3. **Struvite Stone:** Mostly found in women in urinary tract infection. Sometimes this stone can be large and causes urinary obstruction. Basically caused by kidney infection. Diet does not play important role in this type of stone formation.

4. **Cystine Stone:** These types of stones are rarely found. In both men and women they occur suffering from genetic disorder cystinuria or we can say that it results from a genetic disorder that causes cystine an amino acid,

building block of protein, and leak through the kidneys in to the urine to form crystals (hard stone) (Worcester E M et al 2008).

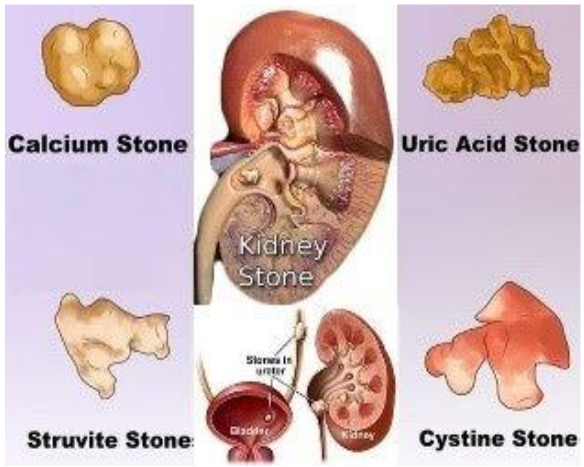


Figure (2.4) Types of renal stone

2.1.7 Symptoms of Kidney Stones

Vomiting, Nausea, Urine infection, Blood in urine, Fever, Foul smell urine and Urinating small amount of urine.

From the above article it is clear how many types of Kidney stones are found in the human body and what are the symptoms when stone is formed in the kidney.

2.1.8 Risk factors for kidney stones:

The greatest risk factor for kidney stones is making less than 1 liter of urine per day. This is why kidney stones are common in premature infants who have kidney problems. However, kidney stones are most likely to occur in people between the ages of 20 and 50.

Different factors can increase your risk of developing a stone. In the United States, white people are more likely to have kidney stones than black people. Sex also plays a role. More men than women develop kidney stones, according to the National Institute of Diabetes and Digestive and Kidney

Diseases (NIDDK). A history of kidney stones can increase your risk. So does a family history of kidney stones (Mollerup et al 2002).

2.2 Kidney Tests: -

Urinalysis: A routine test of the urine by a machine and often by a person looking through a microscope. Urinalysis can help detect infections, inflammation, microscopic bleeding, and kidney damage.

Kidney ultrasound: A probe placed on the skin reflects sound waves off the kidneys, creating images on a screen. Ultrasound can reveal blockages in urine flow, stones, cysts, or suspicious masses in the kidneys.

(CT) scan: A CT scanner takes a series of X-rays, and a computer creates detailed images of the kidneys.

(MRI) scan: A scanner uses radio waves in a magnetic field to make high-resolution images of the kidneys.

Urine and blood cultures: If an infection is suspected, cultures of the blood and urine may identify the bacteria responsible. This can help target antibiotic therapy.

Ureteroscopy: An endoscope (flexible tube with a camera on its end) is passed through the urethra into the bladder and ureters. Ureteroscopy generally cannot reach the kidneys themselves, but can help treat conditions that also affect the ureters.

Kidney biopsy: Using a needle inserted into the back, a small piece of kidney tissue is removed. Examining the kidney tissue under a microscope may help diagnose a kidney problem (Mollerup et al 2002).

2.3 Kidney Treatments:-

Antibiotics: Kidney infections caused by bacteria are treated with antibiotics. Often, cultures of the blood or urine can help guide the choice of antibiotic therapy (Parks J H et al 2003).

Nephrostomy: A tube (catheter) is placed through the skin into the kidney. Urine then drains directly from the kidney, bypassing any blockages in urine flow.

Lithotripsy:-

(ESWL) uses sound waves to break up large stones so they can more easily pass down the ureters into your bladder. This procedure can be uncomfortable and may require light anesthesia. It can cause bruising on the abdomen and back and bleeding around the kidney and nearby organs.(ch1.1.2)

Nephrectomy: Surgery to remove a kidney. Nephrectomy is performed for kidney cancer or severe kidney damage.

Dialysis: Artificial filtering of the blood to replace the work that damaged kidneys can't do. Hemodialysis is the most common method of dialysis in the U/S.

Hemodialysis: A person with complete kidney failure is connected to a dialysis machine, which filters the blood and returns it to the body. Hemodialysis is typically done 3 days per week in people with ESRD. Peritoneal dialysis: Placing large amounts of a special fluid in the abdomen through a catheter allows the body to filter the blood using the natural membrane lining the abdomen. After a while, the fluid with the waste is drained and discarded.

Kidney transplant: Transplanting a kidney into a person with ESRD can restore kidney function. A kidney may be transplanted from a living donor, or from a recently deceased organ donor (Parks J H et al 2003).

2.4 U/S machine:-

2.4.1 The parts of an ultrasound machine:

Transducer probe - probe that sends and receives the sound waves **Central processing unit (CPU)** - computer that does all of the calculations and contains the electrical power supplies for itself and the transducer probe Transducer pulse controls - changes the amplitude, frequency and duration of the pulses emitted from the transducer probe

Display - displays the image from the ultrasound data processed by the CPU **Keyboard/cursor** - inputs data and takes measurements from the display **Disk storage device (hard, floppy, CD)** - stores the acquired images. **Printer** - prints the image from the displayed data. (Peter Hoskins, Kevin martin -2003).

The transducer probe is the main part of the ultrasound machine. The transducer probe makes the sound waves and receives the echoes. It is, so to speak, the mouth and ears of the ultrasound machine. The transducer probe generates and receives sound waves using a principle called the piezoelectric (pressure electricity) effect, which was discovered by Pierre and Jacques Curie in 1880. In the probe, there are one or more quartz crystals called piezoelectric crystals. When an electric current is applied to these crystals, they change shape rapidly. The rapid shape changes, or vibrations, of the crystals produce sound waves that travel out ward. Conversely, when sound or pressure waves hit the crystals, they emit electrical currents. Therefore, the same crystals can be used to send and receive sound waves. The probe also has a sound absorbing substance to eliminate back reflections from the probe itself, and an acoustic lens to help focus the emitted sound waves.

Transducer probes come in many shapes and sizes, the shape of the probe determines its field of view, and the frequency of emitted sound waves determines how deep the sound waves penetrate and the resolution of the image. Transducer probes may contain one or more crystal elements, in multiple-element probes; each crystal has its own circuit. Multiple-element probes have the advantage that the ultrasounc beam can be "steered" by changing the timing in which each element gets pulsed; steering the beam is especially important for cardiac ultrasound. In addition to probes that can be moved across the surface of the body, some probes are designed to be inserted through various openings of the body (vagina, rectum, esophagus) so that they can get closer to the organ being examined (uterus, prostate gland, stomach); getting closer to the organ can allow for more detailed views (Mc Connell et al 1994). Figure (2.5)

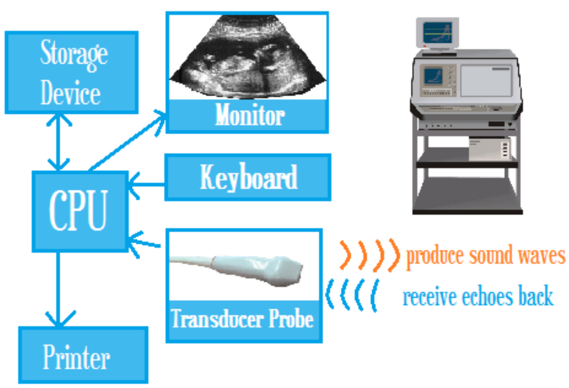


Figure (2.5) U/S Compound

2.5 CT scan machine:-

CT scans Components and Functions:-

CT imaging system is made up of two main components located within the simulator which are:

CT Scanner, Laser System and Scanner Gantry.

The gantry includes the x-ray tube, the detector array, the high-voltage generator, the patient support couch, and the mechanical support for each.

The scanner acquires the image data that will be constructed by the virtual simulation application into 3D virtual model of the patient (Borghi L et al 2002).

A) **X-ray Tube:**

The x-ray tube use in multi slice helical CT imaging have special requirements. The x-ray tube can be energized up to 60s continuously

Some x-ray tube operate at relatively low tube current, however for many the instantaneous power capacity must be high.

B) **Scanner Bore:**

The traditional 70 cm scanner aperture with 50 cm maximum field of view is too limiting for many radiotherapy technique. Therefore, the manufacturer now produce 'large bore' versions providing apertures up to 85 cm which enable most therapy patient to be scanned in an optional position without gantry restriction.

However, the use of wide-bore scanner will results in low contrast resolution and will increase image noise compared standard scanner Focal Spot Size CT imaging systems designed for high spatial resolution imaging incorporate x-ray tubes with a small focal spot.

E) **Detector Array:**

Multislice helical CT imaging systems have multiple detectors in an array up to tens of thousands. Previously, gas-filled detectors were used, but now, all are scintillation, solid state detectors.

Scintillation detectors have high detection efficiency. Approximately 90% of the x-rays incident on the detectors is absorbed.

F) **Scanner Couch:**

A flat, stable couch is essential for radiotherapy planning. Usually made up of carbon fibre which can be adapted to fit any scanner cradle (Borghi L et al 2002).

The couch must be level and orthogonal in its movement through the scanner aperture with maximum deflection of 2mm along its range Figure (2.6) (Kaan orhan - 2019).

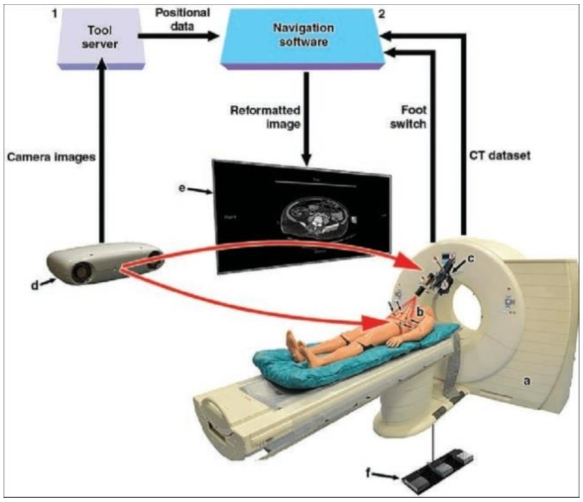


Figure (2.6) CT scan Components

2.6 Lithotripsy machine: -

The introduction of (ESWL) in the early 1980s revolutionized the treatment of patients with kidney stone disease. Patients who once required major surgery to remove their stones could be treated with ESWL, and not even require an incision. As such ESWL is the only non-invasive treatment for kidney stones, meaning no incision or internal telescopic device is required. ESWL involves the administration of a series of shock waves generated by a machine called a lithotripter. The shock waves are focused by x-ray onto the kidney stone and travel into the body through skin and tissue, reaching the stone where they break it into small fragments. For several weeks following treatment, those small fragments are passed out of the body in the urine.

In the two-plus decades since ESWL was first performed in the United States, we have learned a great deal about how different patients respond to this technology. It turns out that we can identify some patients who will be unlikely to experience a successful outcome following ESWL, whereas we may predict that other patients will be more likely to clear their stones. Although many of these parameters are beyond anyone's control, such as the stone size and location in the kidney, there are other maneuvers that can be done during ESWL treatment that may positively influence the outcome of the procedure. At the Brady Urological Institute, our surgeons have researched techniques to make lithotripsy safer and more effective, and we incorporate our own findings as well as those of other leading groups to provide a truly state of the art treatment (Borghi L et al 2002) Figure (2.7)

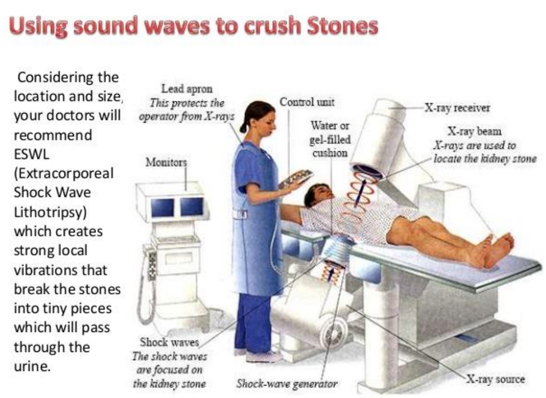


Figure (2.7) lithotripsy machine

2.6.**1Advantages of ESWL:-**

The primary advantage of ESWL is that it is completely non-invasive.

2.6.2 Who should be treated with ESWL?

ESWL is well suited to patients with small kidney stones that can be easily seen by x-ray.

2.6.3 ESWL is not a particularly good treatment for:-

Pregnant patients:

Patients on blood thinners or patients with bleeding disorders. Aspirin or other blood thinners must be discontinued for at least 1 week before ESWL.

Patients with chronic kidney infection, as some fragments may not pass, so the bacteria will not be completely eliminated from the kidney.

Patients with obstruction or scar tissue in the ureter, which may prevent stone fragments from passing. Patients who require immediate and/or complete clearance of stone material, Patients with stones composed of cystine and certain types of calcium, as these stones do not fragment well with ESWL (Borghi L et al 2002.

2.6.4 The ESWL Procedure:

Because ESWL is a completely non-invasive therapy, most ESWL treatments are performed on an outpatient basis. Although the use of anesthesia does depend on patient and physician preference, recent data suggest that the results of ESWL may be improved with the administration of a mild anesthetic. When the patient has been adequately anesthetized, a computerized x-ray machine is used to pinpoint the location of the stone within the kidney. A series of shock waves (several hundred to two thousand) is administered to the stone. Our treatment protocols incorporate the latest research findings which suggest that adjustments of both the shock wave power and the rate at which the shock waves are delivered can affect treatment outcome. Our goal when performing ESWL is to maximize the breakage of a patient's kidney stone while minimizing injury that the shock waves can cause to the kidney and surrounding organs (Borghi L et al 2002).

2.7 Radiation exposure to patients during ESWL:-

ESWL is rapidly becoming an accepted treatment of renal calculi. Since fluoroscopy is involved to image the stones it is important to know how much radiation the patient receives during this procedure. Surface radiation exposure to the patient was measured in more than 300 fluoroscopic and radiographic procedures using thermoluminescent dosimeters (TLD). Initial results showed an average skin exposure of 10.1 rad per procedure for each x-ray unit, comparing favorably with exposure rates for percutaneous nephrostolithotomy and other routine radiological procedures. Factors influencing exposure levels include stone characteristics (location, size and opacity), physician experience and number of shocks required. Suggestions are given that may result in a 50 per cent reduction of radiation exposure.

2.8 Previous study:

Sridhar Sundaramurthy et al 2017An algorithm proposed by Sridhar and Kumaravel is extended to include aframework for the detection of renal calculi. Calculi occur due to abnormal collection ofcertain chemicals like oxalate, phosphate and uric acid. These calculi can be present inthe kidney, ureter or urinary bladder. Performance analysis is done to a set of fiveknown algorithms using parameters such as success rate in calculi detection, bordererror metric and time. The framework is constructed by combining the best algorithmbased on the performance analysis and a procedure to validate the detected calculi usingthe shadow it casts in ultrasound images. Ultrasound images of 37 patients are used fortesting the algorithm. The detected calculi based on the framework match thosedetermined by expert clinicians in more than 95% of the cases.

Wayne Brisbane et al 2016 studied the Kidney stone imaging is an important diagnostic tool and initial step in deciding which therapeutic options to use for the management of kidney stones. Guidelines provided by the American College of Radiology, American Urological Association, and European Association of Urology differ regarding the optimal initial imaging modality to use to evaluate patients with suspectedobstructive nephrolithiasis. Noncontrast CT of the abdomen and pelvis consistently provides the most accurate diagnosis but also exposes patients to ionizing radiation. Traditionally, ultrasonography has a lower sensitivity and specificity than CT, but does not require use ofradiation. However, when these imaging modalities were compared in a randomized controlled trial they were found to have equivalent diagnostic accuracy within the emergency department.Both modalities have advantages and disadvantages. Kidney, ureter, bladder (KUB) plain film radiography is most helpful in evaluating for interval stone growth in patients with known stone disease, and is less useful in the setting of acute stones. MRI provides the possibility of 3Dimaging without exposure to radiation, but it is costly and currently stones are difficult to visualize. Further developments are expected to enhance each imaging modality for the evaluation and treatment of kidney stones in the near future. A proposed algorithm for imaging patients with acute stones in light of the current guidelines and a randomized controlled trial could aidclinicians.

Vishnu Ganesan et al 2016 were determine the sensitivity and specificity ofultrasonography (US) for detecting renal calculi and to assessthe accuracy of US for determining the size of calculi andhow this can affect counselling decisions.We retrospectively identified all patients at our institutionwith a diagnosis of nephrolithiasis who underwent USfollowed by non-contrast computed tomography (CT) within60 days. Data on patient characteristics, stone size (maximumaxial diameter) and stone location were collected.

Thesensitivity, specificity and size accuracy of US was determinedusing CT as the standard.

ResultsA total of 552 US and CT examinations met the inclusioncriteria. Overall, the sensitivity and specificity of US was 54and 91%, respectively. There was a significant associationbetween sensitivity of US and stone size ($P<0.001$), but notwith stone location ($P=0.58$). US significantly overestimatedthe size of stones in the 0–10 mm range ($P<0.001$).Assuming patients with stones 0–4 mm in size will beselected for observation and those with stones≥5 mm couldbe counselled on the alternative of intervention, we foundthat in 14% (54/384) of cases where CT would suggestobservation, US would lead to a recommendation forintervention. By contrast, when CT results would suggestintervention as management, US would suggest observation in39% (65/168) of cases. An average of 22% (119/552) ofpatients could be inappropriately counselled. Stones classified as 5–10 mm according to US had the highest probability(43% [41/96]) of having their management recommendationchanged when CT was performed. The use of plainabdominalfilm of kidney, ureter and bladder and USincreases sensitivity (78%), but 37% (13/35) of patients maystill be counselled inappropriately to undergo observation.

ConclusionsUsing US to guide clinical decision-making for residual orasymptomatic calculi is limited by low sensitivity and inabilityto size the stone accurately. As a result, one in five patientsmay be inappropriately counselled when using US alone.

Haewook Han et al 2015 studied The incidence of kidney stones is common in the United States and treatments for them are very costly. This review article provides information about epidemiology, mechanism, diagnosis, and pathophysiology of kidney stone formation, and methods for the evaluation of stone risks for new and follow-up patients. Adequate evaluation and management can prevent recurrence of stones. Kidney stone prevention should be individualized in both its medical and dietary management, keeping in mind the specific risks involved for each type of stones. Recognition of these risk factors and development of long-term management strategies for dealing with them are the most effective ways to prevent recurrence of kidney stones.

Mohamed Yousef et al 2013, This study assessed the effectiveness of computed tomography and ultrasound in the diagnosis of renal stone and compared between two images modalities when they are applied for the same cases. It was conducted at radiology departments in Al-amal hospital _ Khartoum. This study was expanded from August 2011 up to December 2011. Random samples of 50 patients, 35males (70%)and 15 females (30%)their ages range from 15 to 72 years old with symptoms of renal stones were chosen, spiral CT and US were done to explain the suitable technique that demonstrate renal stones clearly . The most affected age group from 21-40 years old represent 56 %, most patients were affected in the both sides, with no history of renal stones in their families, kidneys were the most affected area, and Most patients suffer from kidney stones (36%) and ureters 6%). Ultrasound images have a role in the diagnosis of renal stones but CT scan is better and more sensitive. These results are established by account the number of appearances that showing in CT images and compared them with those appeared in ultrasound images It can be said that the two image modalities were performed together and used as essential techniques of renal stones, which help to obtain accurate diagnosis and demonstrate any changes that can affect urinary systems by stones.

AndrzejWróbel et al 2013 studied Two issues related to nephrolithiasis are explored: does the chemical composition and morphology of renal calculi in South Poland overlap with the studies from other countriesand (2) are there possibilities to evaluate in vivo chemical composition of stones using computed tomography. The study was conducted on 108 renal stones. X-ray fluorescence, X-ray diffraction and Fourier transformed infrared spectroscopy were used to determine the chemical composition. The morphologyof the stones was examined using micro computed tomography.The stone chemical composition in South Poland indicate that calcium oxalate monohydrate was overwhelmingly dominant (84%) followed by hydroxyapatite (8%) and struvite (6%). The occurrence of uric acid stones was very low (2%). The relative frequency of various stone types is similar in South Poland to other industrialized countries. The studied renal stones were characterized by a large variability in the concentrations of both major and trace elements. The maximum/minimumconcentration ratio exceeds two orders of magnitude. Significant morphological differences have beenobserved between different types of stones. The stones were composed of oxalate polyhedrons stuck together or had the phosphate core overlaid with layers oxalate and organic mater. The use of CT toidentify stone type seems to be limited.

Punal M Arabi et al 2013 studied the Kidney stone disease is one of the risks for life throughout the world and majority of people with stone formation in kidney atthe initial stage do not notice it as disease and it damages the organ slowly. Current estimation is that there are 30 million people suffering bythis disease. The currently available widely used low cost imaging techniques for diagnosing kidney diseases include X -ray imaging and Ultrasound imaging. This paper proposes an approach for the classification of different types of Kidney stones using gray level co-occurrence matrix (GLCM) features namely contrast, co-relation, energy and homogeneity. Different types of Kidney stones namely Struvite stones, Stag horn stones and Renal Calculi stones were analyzed and the results obtained show that the proposed GLCM feature analysis meth od could be used to classify kidney stones. The results obtained further show that there is a possibility of developing CAD and computer aided classification of kidney stones by the proposed texture analysis method

Michael Mitterberger 2009 compare the detection of urinary stones using standard gray scale ultrasound for diagnostic accuracy using the color Doppler "twinkling sign". the study population consisted of forty-one patients who demonstrated at least one urinary stoneon unenhanced CT evaluation of the kidneys or ureters. Each patient was evaluated using gray scale ultrasound and color Doppler imaging by an observer who was blinded to the CT results.Results: Seventy-seven stones were present in 41 patients, including 47 intrarenal stones, 5 stones in the renal pelvis, 8 stones at the ureteropelvic junction, 5 ureteral stones and 12 stones at the ureterovesical junction. Based upon gray scale sonography the diagnosis of stone was made with confidence in 66% (51/77) of locations. Based upon Doppler sonography using the twinkling sign, the diagnosis of stone was made with confidence in 97% (75/77) of locations. Clustered ROC analysis demonstrated that the Doppler twinkling sign (Az = 0.99) was significantly better than conventional gray scale criteria (Az = 0.95) for the diagnosis of urinary stones (p = 0.005, two-sided test).Conclusions: The color Doppler twinkling sign improves the detection, confidence and overall accuracy of diagnosis for renal and ureteral stones with minimal loss of specificity.

Chapter Three

Materials and Methods

3.1 Introduction

This Study intended to classification of renal stone using U/S scan from different soft images of U/S machine during abdomen U/S. The data of this Study was collected from three clinical centers in Elobied.(University of kordufan diagnostic centre, Elsalama clinic Centre and Eldaman hospital) and by data sheets, U/S soft image and CT KUB reports , the data has been collected from April 2019 to October 2019.

3.2 U/S, CT & lithotripsy Machines:-

In the present study two U/S, two CT scan and lithotripsy machines, from different manufactures were used as described in Table (3.1) figure (3.1, 3.2, 3.3, 3.4 and 3.5).

Table (3.1) U/S, CT & lithotripsy Machines

Type of Equipment	Centre	Company	Year of installation
CT (128) slice	DH	Neusoft	2018
CT(16) slice	U.K	GE	2007
U/S	U.K	Mindray	
U/S	EC	SIUI	
Lithotripsy	U.K	Dornier delta II	2007

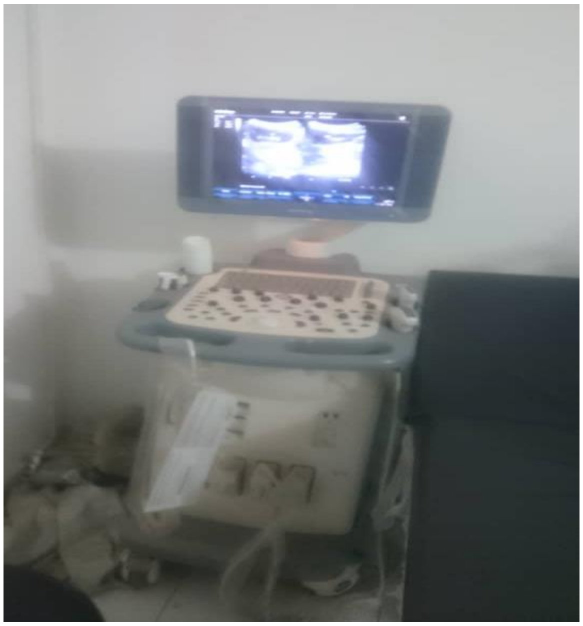


Figure (3.1) UK- U/S machine

Figure (3.2) UK- CT machine

Figure (3.3) EC- U/S machine

Figure (3.4) DH- CT machine

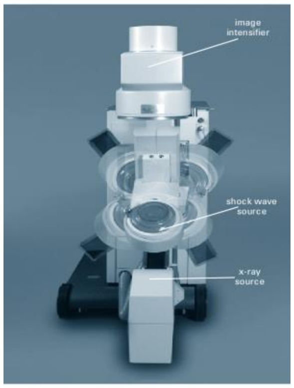


Figure (3.5) UK- Lithotripsy machine

3.3 Patient samples:-

A total of 90 patients were examined in three centers in Elobied, Data were collected using a data collection sheet for all patients in order to maintain consistency of the information (Appendix1). The following parameters were recorded (Pt code, age, Gender, Stone density, stone size derived from (width* length) cm^2 and Stone site were recorded (Appendix2).

3.4 Imaging technique:-

A kidney ultrasound may be performed on an outpatient basis or as part of your stay in a hospital. Although each facility may have different protocols in place, generally an ultrasound procedure follows this process: You will be asked to remove any clothing, jewelry or other objects that may interfere with the scan. If asked to remove clothing, you will be given a gown to wear. You will lie on an examination table on your abdomen. Ultrasound gel is placed on the area of the body that will undergo the ultrasound examination Using a transducer, a device that sends out the ultrasound waves, the ultrasound wave will be sent through that patient's body. The sound will be reflected off structures inside the body and the ultrasound machine will analyze the information from the sound waves. The ultrasound machine will create images of these structures on a monitor. These images will be stored digitally. If the bladder is examined, you will be asked to empty your bladder after scans of the full bladder have been completed. Additional scans will be made of the empty bladder. There are no confirmed adverse biological effects on patients or instrument operators caused by exposures to ultrasound at the intensity levels used in diagnostic ultrasound. While the kidney ultrasound procedure itself causes no pain, having to lie still for the length of the procedure may cause slight discomfort and the clear gel will feel cool and wet. The technologist will use all possible comfort measures and complete the procedure as quickly as possible to minimize any discomfort figure (3.6).

Figure (3.6) U/S Scan

In CTKUB You may be asked to change into a patient gown. If so a gown will be provided for the patients. A locker will be provided to secure personal belongings. Please remove all piercings and leave all jewelry and valuables at home, are most frequently done with and without a contrast media. The contrast media improves the radiologist's ability to view the images of the inside of the body. Some patients should not have an iodine-based contrast media. If the patients have problems with your kidney function, please inform the access center representative when the patients schedule the appointment, the patients may be able to have the scan performed without contrast media or have an alternative imaging exam. The most common type of CT scan with contrast is the double contrast study that will require the patients to drink a contrast media before the patients exam begins in addition to the IV contrast. The more contrast you are able to drink, the better the images are for the radiologist to visualize your digestive tract. Figure (3.7)

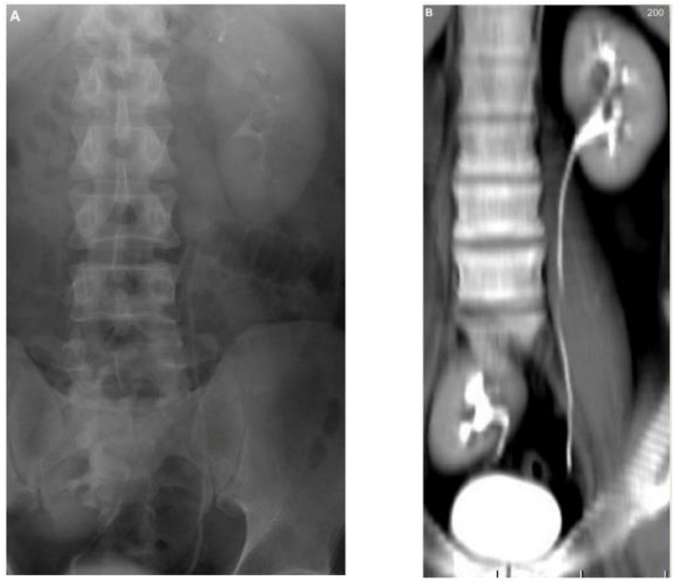


Figure (3.7) CTKUB with contrast

3.5 Lithotripsy technique:-

To removes stones using shock wave treatment. Using x-rays to pinpoint the location of the stones, the patient on top of a soft cushion or membrane through which the waves pass. About 1- 4 thousand shock waves are needed to crush the stones. The complete treatment takes about 45 to 90 minutes. Figure (3.8) (David W, CharlesJ. Yeo John H, McFadden -2012)

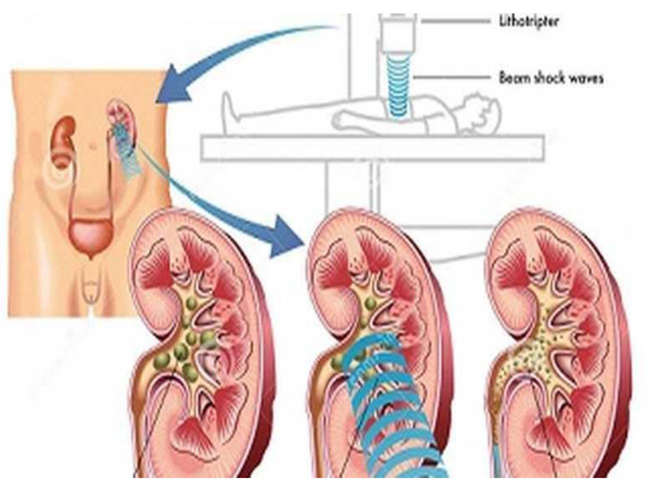


Figure (3.8) Lithotripsy technique

3.6 Patient preparations:-

There is no advance preparation necessary for routine U/S and CT KUB. A hospital and diagnostic centers gown is used to remove all clothing on the middle body (in U/S Exam) and all jewelry must be removed from the examined organ (in CT Exam). Some patients were needed to contrast to Explainer the urine bath from kidney ureter to bladder (in CT Exam), before the examination, the radiographer explained the procedure to all patients. All examinations were performed according to the technique used in each hospital and Diagnostic centre.

3.7 Image protocol:-

In CT KUB Scan the exposure parameters selected automatically during patient weight and organ size. And in U/S Scan the probe (Hz) selected during a patient weight and the image angle.

3.8 Samples:-

Total of 90 patients from three centreswith CT KUB& abdomen U/S.

3.9 Area of the study:-

This study was carried in (University of kordufan diagnostic centre, Elsalama clinic centre&Eldaman hospital) in Elobied NKS in Sudan.

3.10The duration of the study:-

The period from April 2019 to October 2019.

3.11The data collection:-

The data was collected from the patients, technologist, Radiologist and measuring the U/S stone density.

3.12 Data analysis:-

The data was analyzed by IDL, SPSS and M.s excel.

Chapter four

Results

4.1 Results

Table (4.1) Multiple linear regression coefficient and the selected variables for prediction of stone types.

Coefficients	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig.
	B		Beta		
(Constant)	2.587	.471		5.488	.000
Entropy	.008	.002	6.573	3.504	.001
Kurtosis	.370	.047	.493	7.844	.000
Variance	.0001	.000	-.202	-3.203	.002
Mean	-.066	.021	-5.985	-3.192	.002
Dependent Variable: stonetype					

This means:

$$Stone\ type = (0.008 \times Entropy) + (0.370 \times Kurtosis) + (0.0001 \times Variance) + (-0.066 \times mean) + 2.587$$

Table (4.2) Multiple linear regression coefficient and the selected variables for prediction of stone density.

Coefficients	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	1711.252	500.113		3.422	.001
Entropy	6.616	2.549	5.373	2.595	.011
Kurtosis	300.439	50.083	.416	5.999	.000
Variance	-.402	.139	-.202	-2.893	.005
Mean	-50.392	21.827	-4.779	-2.309	.023
Dependent Variable: density					

$$Stone\ type = (6.61 \times Entropy) + (300.4 \times Kurtosis) + (-0.402 \times Variance) + (-50.39 \times mean) + 1711.25$$

Table (4.3) Classification coefficient of stone type into two classes with the selected first order features

Classification Function Coefficients		
	Stone type	
	type 1 (<1000)	type 2 (> 1000)
Mean	11.206	10.392
Variance	.010	.005
Kurtosis	-11.562	-6.967
Entropy	-1.315	-1.211
(Constant)	-132.670	-118.775
Fisher's linear discriminant functions		

$$stone\ type1 = (mean\ \times 11.2) + (Variance \times 0.01) + (Kurtosis \times -11.562) + (Entropy \times -1.315) + (constant \times -132.670)$$

$$Stone\ type2 = (mean\ \times 10.39) + (Variance \times 0.005) + (Kurtosis \times -6.96) + (Entropy \times -1.211) + (constant \times -118.775)$$

Table (4.4) Classification score using linear discriminant analysis

Stone type			Predicted Group Membership type 1 (<1000)	Predicted Group Membership type 2 (> 1000)	Total
Original	Count	type 1 (<1000)	**54**	0	54
		type 2 (> 1000)	3	**33**	36
	%	type 1 (<1000)	**100.0**	0.0	100.0
		type 2 (> 1000)	8.3	**91.7**	100.0
96.7% of original grouped cases correctly classified.					

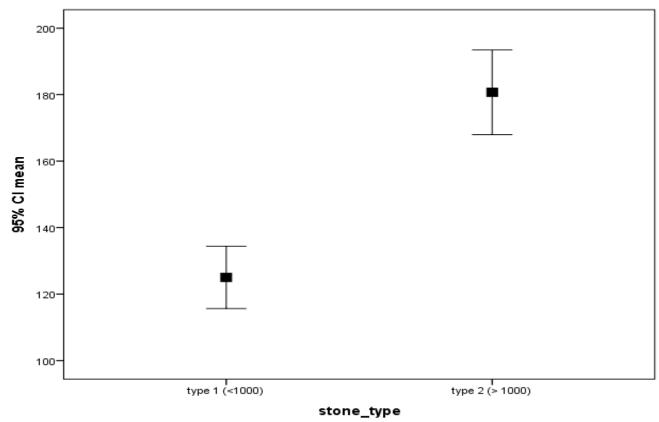


Figure (4.1) An error bar show the average of the first order feature the mean for the stone types

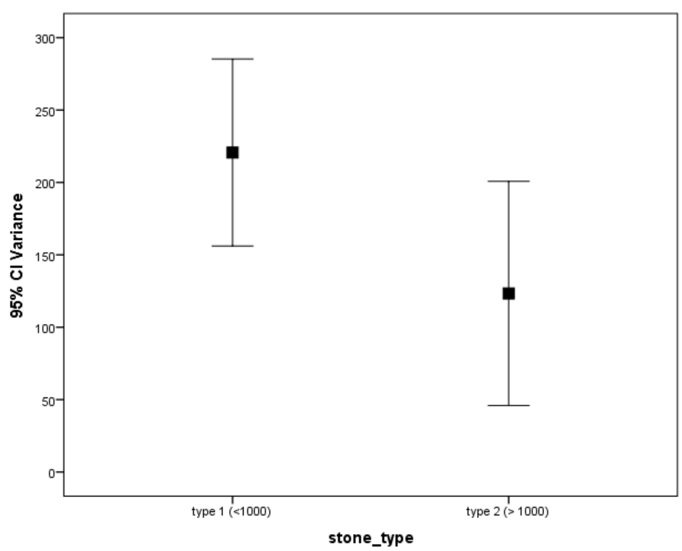


Figure (4.2) An error bar show the average of the first order feature the mean for the stone types

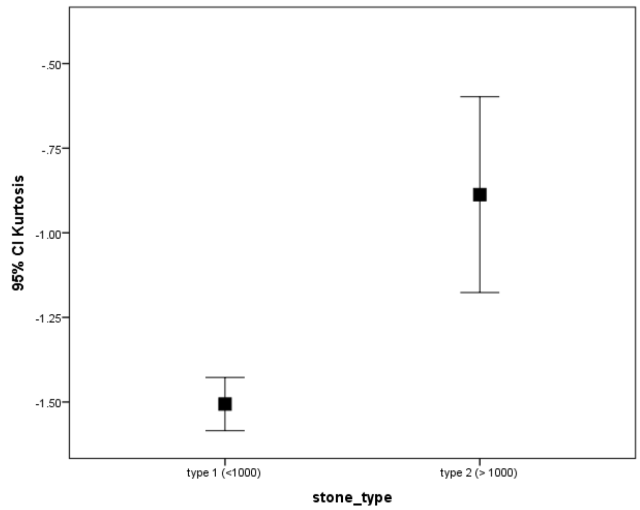


Figure (4.3) an error bar show the average of the first order feature the kurtosis for the stone types

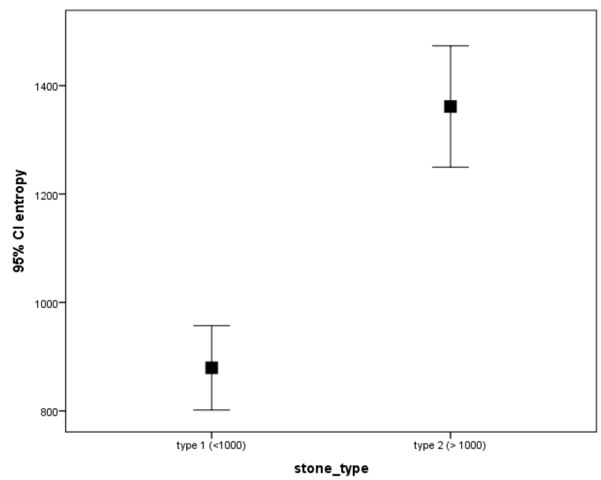


Figure (4.4) An error bar show the average of the first order feature the entropy for the stone types

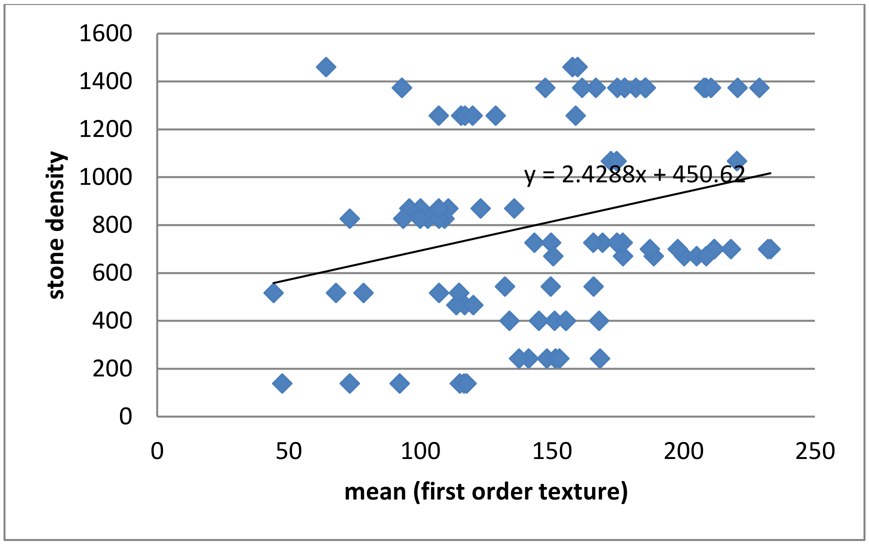


Figure (4.5) Scatter plot show a direct linear relation of the mean (feature) with stone density

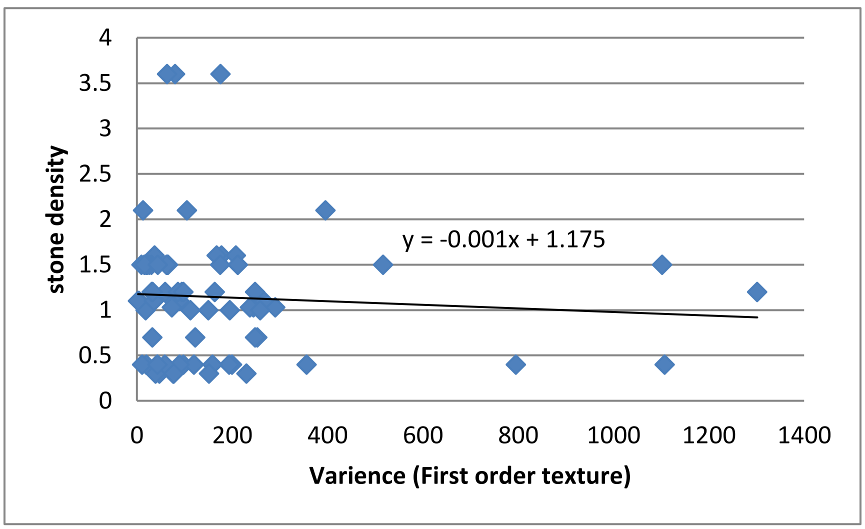


Figure (4.6) Scatter plot show a direct linear relation of the variance (feature) with stone density

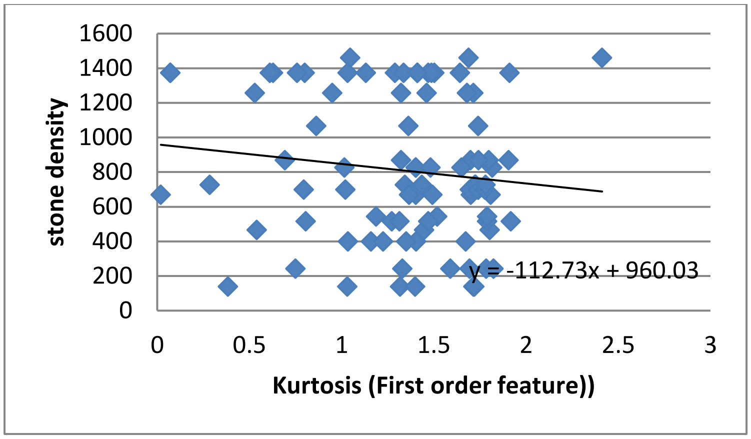


Figure (4.7) Scatter plot show a direct linear relation of the kurtosis (feature) with stone density.

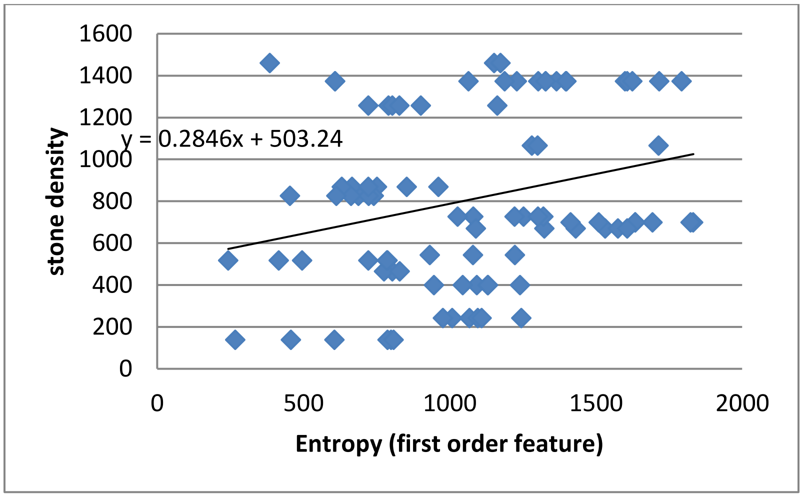


Figure (4.8) Scatter plot show a direct linear relation of the entropy (feature) with stone density.

Chapter five

Discussion, Conclusion and Recommendations

5.1 Discussion:

This Study is intended to Classify of renal stone type using ultrasound machine in Elobied N.K.S in the Sudan. The stone type was measured to 90 patients (CT & U/S) in three centers in Elobied, The mean stone density in this study was found to be 808 HU, the results summarized in table (3.2). The mean of stone length was found 1.54 cm, the mean stone width was found 1.09 cm, while the mean age of patient was 49 years and the mean stone Area was 2.27 cm^2 ، 12 patients female and 78 males, 61 patient type one and 29 type two. As in lit the stone density less than 1000HU named as **type one** and more than 1000HU as **type two** using CT in this study and texture analysis that Extracted from the stone it has been found that there is linear relationships between the stone type and the texture feature that extracted from the stone shown Ultrasound image, these first order statistics feature include entropy, Kurtosis, variance and means. For stone type can use the following Equation:

$$\text{Stone type} = (0.008 \times \text{Entropy}) + (0.370 \times \text{Kurtosis}) + (0.0001 \times \text{Variance}) + (-0.066 \times \text{mean}) + 2.587$$

As shown in table (4.1)

Similarly using these first features (entropy, Kurtosis, variance, and means) extracted from ultrasound image density value of the stone can be estimated using the following multiple linear regression equation:

$$Stone\ type = (6.61 \times Entropy) + (300.4 \times Kurtosis) + (-0.402 \times Variance) + (-50.39 \times mean) + 1711.25$$

As shown in table (4.2)

In order to classify the stone into type one and two using linear demonstrate analysis and texture feature as input data, the result of classification showed that the overall accuracy was 96.7% and for stone type one was 100% and type two was 91.7% as shown in table (4.3) and (4.4) using the following linear discriminate equation:

$$s\text{tone type1} = (\text{mean } \times 11.2) + (\text{Variance} \times 0.01) + (\text{Kurtosis} \times -11.562) + (\text{Entropy} \times -1.315) + (\text{constant} \times -132.670)$$

$$\text{Stone type2} = (\text{mean } \times 10.39) + (\text{Variance} \times 0.005) + (\text{Kurtosis} \times -6.96) + (\text{Entropy} \times -1.211) + (\text{constant} \times -118.775)$$

The texture feature means usually different between stone type where it show high value for the stone type two (figure 4.1), white variance show higher scatter for stone type one reflow to stone type two but as the centre of class these is differences and the extreme values show over loping point figure (4.2) in the same way kurtosis differentiate between the two type of stone where type one show low kurtosis with mini mean distribution while type two give high kurtosis and distribution figure (4.3) finally entropy which demonstrate the randomness it gives low value for stone type one in respect to type two figure (4.4). As the mean texture increases the stone density increases linearity. Where the density increase by 2.4 HU per one unite of texture feature mean starting at 451 figure (4.5), also the stone density decreases by 0.001 unite per one unite of variance figure (4.6). as well as it decreases by 112.7 HU per one unite of kurtosis 960 HU figure (4.7), finally stone density increases as entropy 0.28 HU per one unite of entropy starting 503HU figure (4.8).

5.2 Conclusions:-

The results obtained show that the texture features could be used to classify kidney stones. By analyzing many more images by IDL and other statistical methods a suitable decision rule can be found in future.

This Study is intended to Classify of renal stone type using ultrasound machine in Elobied N.K.S in the Sudan. The stone type was measured to 90 patients (CT & U/S) in three centers in Elobied, The mean stone density in this study was found to be 808 HU, The mean of stone length was found 1.54 cm, the mean stone width was found 1.09 cm, while the mean age of patient was 49 years and the mean stone Area was 2.27 cm^2 ,12 patient female and 78 males, 61 patients type one and 29 type two. As in lit the stone density less than 1000HU named as **type one** and more than 1000HU as **type two** using CT in this study and texture analysis that Extracted from the stone it has been found that there is linear relationships between the stone type and the texture feature that extracted from the stone shown Ultrasound image, these first order statistics feature include entropy, Kurtosis, variance and means. For stone type can use the following Equations:

$$\textbf{Stone type} = (\mathbf{0.008} \times \textbf{Entropy}) + (\mathbf{0.370} \times \textbf{Kurtosis}) + (\mathbf{0.0001} \times \textbf{Variance}) + (-\mathbf{0.066} \times \textbf{mean}) + \mathbf{2.587}$$

$$Stone\ type = (6.61 \times Entropy) + (300.4 \times Kurtosis) + (-0.402 \times Variance) + (-50.39 \times mean) + 1711.25$$

$$s\text{tone type1} = (\text{mean } \times 11.2) + (\text{Variance} \times 0.01) + (\text{Kurtosis} \times -11.562) + (\text{Entropy} \times -1.315) + (\text{constant} \times -132.670)$$

$$\text{Stone type2} = (\text{mean } \times 10.39) + (\text{Variance} \times 0.005) + (\text{Kurtosis} \times -6.96) + (\text{Entropy} \times -1.211) + (\text{constant} \times -118.775)$$

5.3 Recommendation:

- Further study can be done using stone compound.
- Study can be done by using three classes for the stone with density less than1000HU.
- Estimation of stone density from U/S using the model can be test on large group.
- In future the U/S machine company can be setup the IDL programs in new models.

5.4 References:

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Appendix 1

Sudan University of science and technology

Data collection sheet

No	date	Hospital name	Pt. No	Age	Stone Density	Stone width	Stone length	CT machine	U/S machine
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
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17									
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29									
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31									
32									
33									
34									
35									
36									
37									

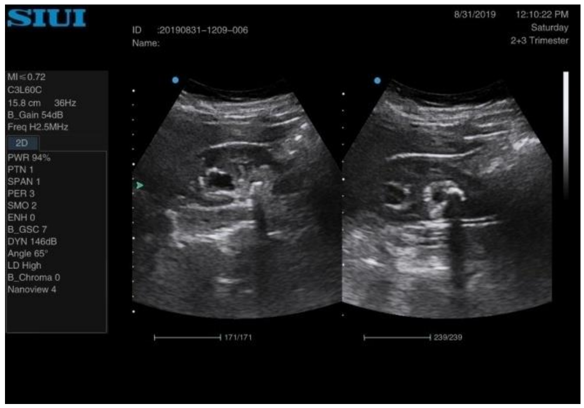
Appendix 2

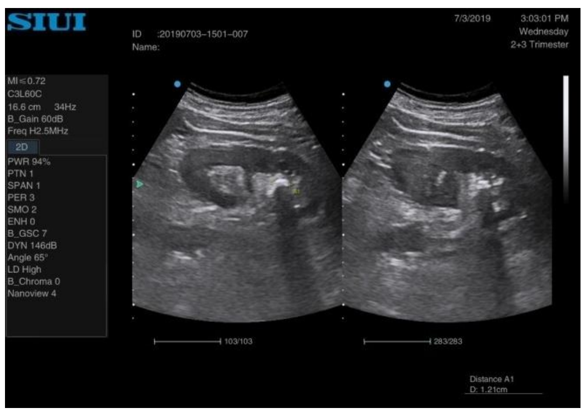
Patients Data table

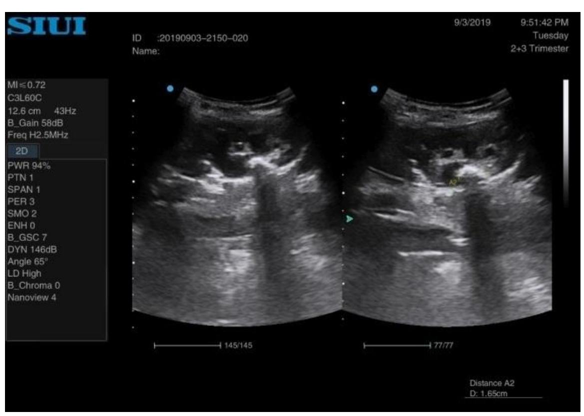
NO	Mean	Variance	skewness	Kurtosis	energy	entropy	Gender	Age	Density	stone_length	stone_Width	stone_area	site	stone_type
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														

Appendix 3

Renal Stone Soft Images





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Adult ABD
DC-N6
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F3.5 / D14.8
G50 / FR45
IP4 / DR95
1 Dist 0.73 cm
2 Dist 0.30 cm
134/134


mindray
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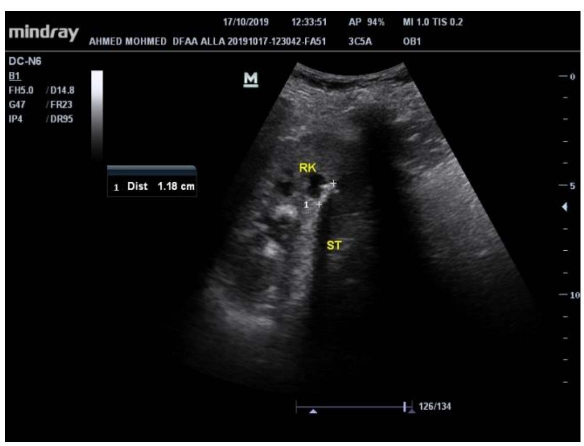
G47 / FR23
IP4 / DR95
1 Dist 1.18 cm
RK
ST
126/134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12:33:51
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AHMED MOHMED DFAA ALLA 20191017-123042-FA51
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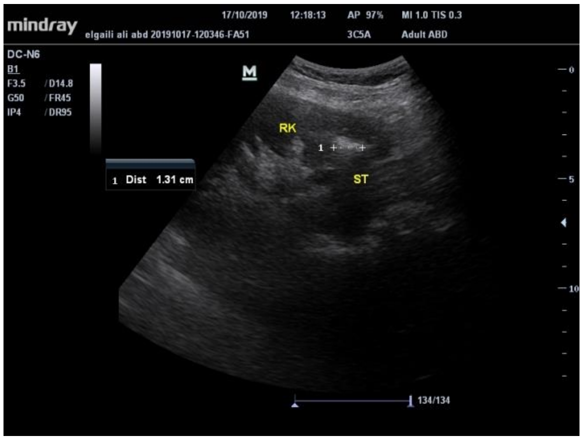
RK
ST
126/134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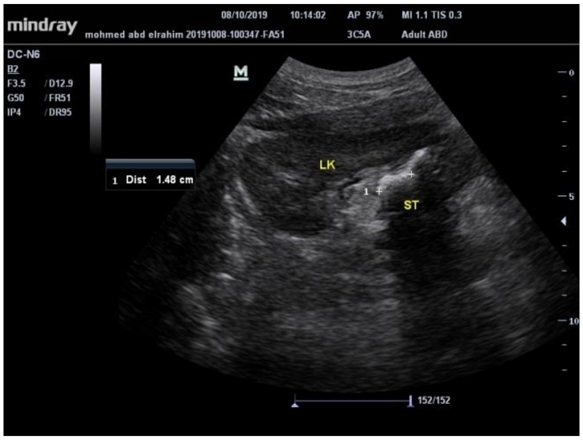
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M
LK
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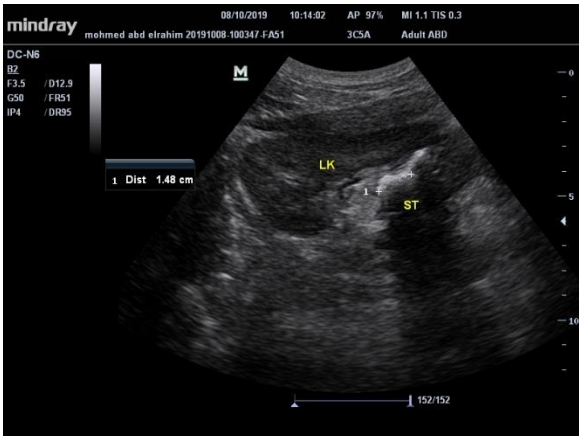
152/152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M
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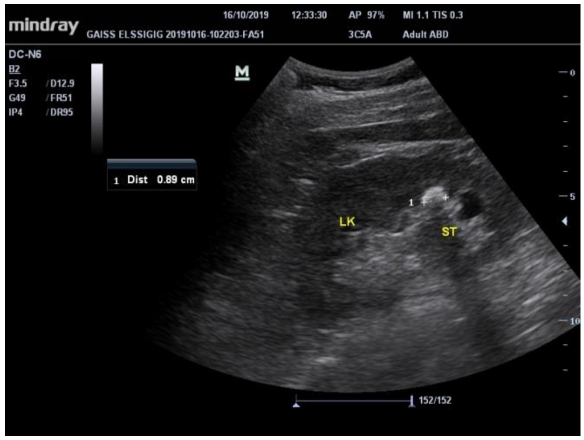
152/152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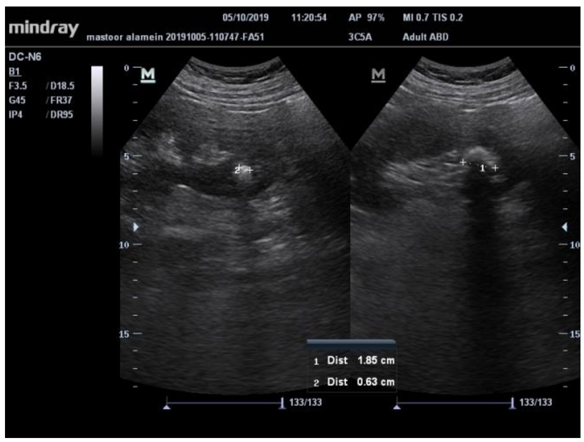
152/152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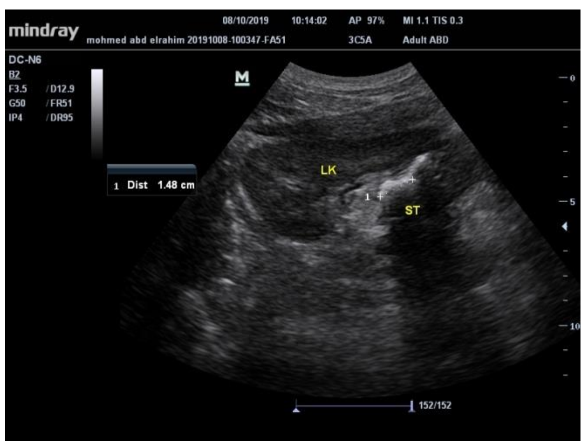
133/133
133/133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G50 /FR51
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LK
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152/152


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B1
F3.5 /D14.8
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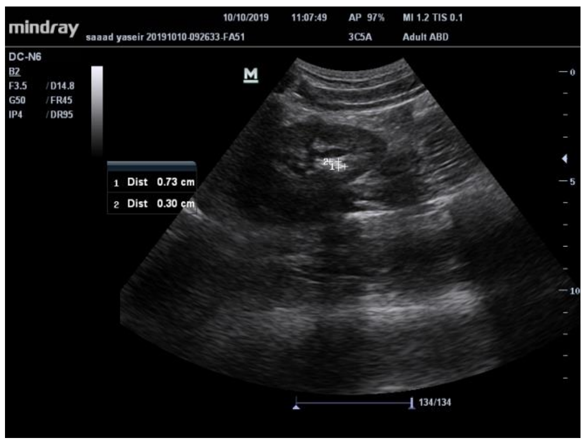
LK
ST
134/134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2 Dist 0.30 cm
134/134


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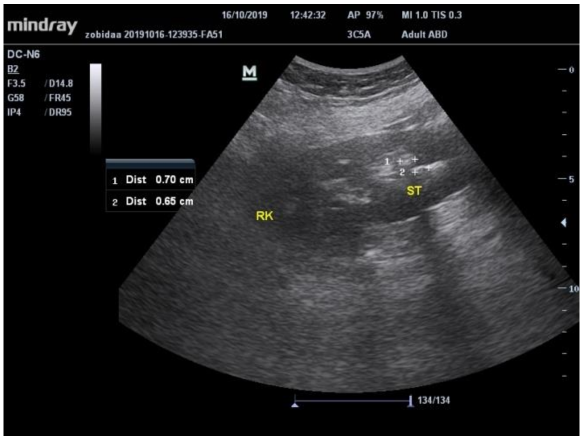
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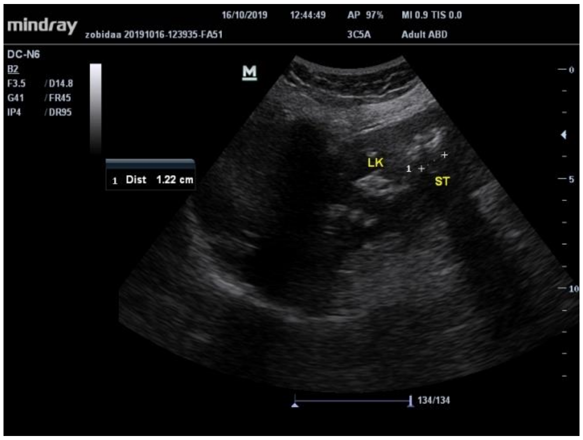
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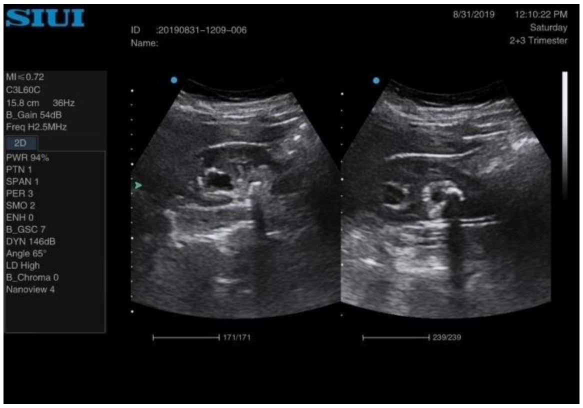
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