Use Of Nonenhanced Computed Tomography In Predicting Renal Stone Composition

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ABSTRACT

Urinary stone define as hard mass in urinary tracts and might be causes pain bleeding infection and some times obstruct urine flow. These symptoms related to stone size and location in urinary tracts, smallest one cause no symptoms but large stone manifested one or all of mentioned above symptoms. Management of urinary stone depends up on stone composition and the fragility. Therefore, knowing composition of stone determine the treatment approach and appropriate pathway to relive the problem. In addition verifying the composition need to laboratory analysis. Aim of study it was Studied the ability of nonenhanced CT scan in term of HU and HD parameters to predict the stone composition. Patients and methods A cross sectional study was enrolled patients suffering from renal stone that visited urological clinic in Babylon teaching hospital and Karbala teaching hospital from 1st June to 1st September 2020. Forty patients were included and investigated about stone characters (size, diameter and shape), patients had single stone > 10 mm in diameter the diagnosis was made by urologist used ultrasound device they referred patient for KUB x-ray and non-enhanced CT scan. In a results The study was enrolled 40 patients with mean age 43.1±15.9. The male to female ratio was 2.4:1. The study show six groups of stone, pure calcium oxalate, pure uric acid, pure struvite, mixed Calcium Oxalate + HXA, Mixed Calcium Oxalate + HXA + STR and Mixed Calcium Oxalate + UA. Pure Calcium Oxalate stone more frequent were found in the study in 35%, 17.5% pure UA and 22.5% pure STR. there were significant relation between stones types and Hounsfield units. In addition, there were to significant relation between stone type and Hounsfield density values. We Conclude that Nonenhanced CT can determine the chemical composition of most renal stone types by measuring the Hounsfield Unit and Hounsfield density of the stone.

Key words: Renal stone , CT scan, Hounsfield units, Hounsfield density.

1. INTRODUCTION:

Urinary stone define as hard deposit in urinary tracts and may cause pain, hematuria, infection and some time obstruct urine flow. These symptoms related to stone size and location in urinary tracts, smaller one cause no symptoms but large stone manifested one or all of mentioned above symptoms[1]. Usually name of stone depend on location of it, such stone locate din kidney called kidney stone whereas calculi site in ureter called ureteric stone. Urolithiasis or nephrolithiasis refer to process of stone formation[1]. Size of stone variable from patient to other and range from very small difficult to seen by naked eye to one inch or more in diameter. Larger stone called staghorn with many projections from outer layer that trapped in renal pelvis[2].

1.1 Epidemiology:

Annually in united state there was 1 of 1000 of hospitalized adult suffering from urinary stone. Most age effected were 20-60 years old [1]. Furthermore, urinary stone is documented to be increased overall the world. The risk factors are multiple, apart from un modifiable factors age and sex, the factors that play a major role in formation of stone such as high intake calcium in diet and oxalate, low fluid intake and meals rich animal protein[3]. Because of high incidence the urolithiasis, it had impact on health cost outcome. In developed countries had been show increase in prevalence of urinary calculi due to enhanced in standard of living and it had frequency with specific race. In addition there is a cyclic change with season, men had be effected mostly in summer while female presented more in winter[4]. Gender difference also present, men complain from stone twice as female. The peak age about thirty years while in female show two peak normal distribution 34 years and about 50 years[3].

The geographical distribution variable too, with specific countries had high incidence such as island of British, countries in center of Europe, north of Australia and middle east countries [4]. The belt of stone formation countries in the world that show different age of presentation with male more than female these countries from Egypt to Indonesia, middle east to south of Asia [5].

1.2 kidney anatomy:

The site of kidney in posterior wall of abdomen it located retroperitoneal back gutter. The upper poles more medially and posteriorly than lower pole. kidney measure about 10-15 cm in length, the right kidney lower than left. The kidney composed from inner (medulla) and outer layer (cortex). Had seven pairs of calyces. The calyces paired to form the pelvis. There are upper calyces , middle and lower. The hilum of kidney lie medially left kidney at L1 and right at L1/L2 which is lower than left[2]. The renal artery and vein lie anterior to renal pelvis. Some times the renal artery may be branched to form posterior renal artery that enter kidney posterior to pelvis of kidney, nerve and lyphm enter at hilum of kidney [6].

1.3 Causes of stone formation :

1-Un equilibrium between stone inhibitors formation with high saturated of urine with salt lead to stone produces. Normally citrate is an inhibitor that binds with calcium to prevent stone formation [7].

2-Renal stone are common seen in individual with specific diseases such as hyperparathyroidism, renal acidosis and dehydration.

3- They more presented with person they ingested high protein diet especially from animal source and increase calcium in their food.

4-More often individual with family history with renal stone prevalent in family had manifested also stone formation.

5-Patients that had surgery for weight reduction have increase chance to stone presentation [8].

6-drugs may be implementing in these order such as indinavir.

1.4 Factors affect stones creation:

1.4.1 Intrinsic factor

Age: age from twenty to fifty shows the peak of occurrence of stone formation

Sex; previously most studies report that males are affected 3 times as frequently as females. Testosterone may cause increased oxalate production in the liver (predisposing to CO stones) and women have higher urinary citrate concentrations (citrate inhibits CO stones formation). Nowadays the gender gap is closing where the new studies in USA reports that the ratio is 1.3-1[9].

Genetic; renal stone more common reported in patients with positive family history of stone formation. Many study still recorded high rate of renal stone in spite of calcium low diet in patients of family history. renal tubular acidosis inherited diseases predisposing to formation cystinuria and calcium phosphate stone[10].

1.4.2 Extrinsic factor:

a. Weather season and location

Many report about correlation of extrinsic factors and renal calculi and these relation complex. In hot climate predisposing to renal stone, on other hand, black Africans had low incidence of calculi. More over, population of Europe have high rate of formation of renal stone. Explanation for this may be due to sedentary and westerian life style or genetic factors superimposed or alone share in renal calculi formation(9).Calculi more common in summer season due to concentrated urine and low PH enhance cysteine and uric acid stone production. In addition in summer there are increase of sun exposure leading to increment in vitamine D productions (hypercalciuria) [10].

b. Diet and water:

Decrease of fluid intake less than 1200cc/day and high animal sources of protein are the major role in renal stone formation. Protein consumption in large amount lead to low urine PH, high oxalate and decrease citrate in urine [10].

Occupation; sedentary occupations incline to calculi more than manual work.

1.5 Pathophysiology:

Urine is said to be saturated with, for example, calcium and oxalate, when the product of the concentrations of calcium and oxalate exceeds the solubility product. Below the solubility product, crystals of calcium and oxalate will not form and the urine is under saturated [11]. In some circumstance the inhibitors of crystallization not work effectively leading to formation of crystals. At this level the supersaturation of urine is reach the crystallization will be start. The urine describe as metastable when calcium and oxalate concentration reach this level[12] . Presence of variable amount of inhibitors of crystallization give the urine more power to withhold solute in solution than water. Such as citrate combine with calcium to inhibition them from formation of calcium oxalate and calcium phosphate[12]. Magnesium and glycosaminoglycans are also consider crystallization inhibitors.

Variable times of supersaturation of urine may occur with different substances for example following dehydration or meals. As early on the nucleation phase is happened which consider the first phase of crystallization, that consist from crystals or epithelial cell. After this, will occur aggregation of nuclei of crystals [13].

Table 1.1 : Calculi formation stages.

Calicium and oxalaite concentration lower than solubility products	No calculi formations
Metastable calicium and oxalaite concentration	No calculi formations
Calicium and oxalaite concentrations more than formation products	Stones formation

In the urine of subject who do not form stone, the concentrations of most stone components are between the solubility product and the formation product.

1.6 Renal Stone types

The urine that more liable to form stone are likely prone to produce renal calculi, occasionally the crystal grows to form stone. Most common types of stone are calcium in range 70-80% and other materials are uric acid, cysteine and struvit. Struvit calculi are combination of magnesium, ammonium, and phosphate mostly occur after infection of urine [10].

1.6.1 Calcium-oxalate stone :

It happen in 3 crystalline form:
a. Calicium-oxalate monohydrat (COM)
b. Calicium-oxalate dihydrat (COD)
c. Calicium-oxalate trihydrat (COT)
Calcium oxalate nearly all consist of pure calcium oxalate, while some times, presented in conjugated with phosphate or urate. Hypercalciurea are the most common causes for calcium stones, in addition to low urine volumes, low urine PH, high protein diet, hot weather, congenital anomaly and inhibitors action[14].

1.6.2 Uric acid stone

Approximately 5-9% of renal calculi. However the body in capable to change insoluble uric acid to soluble form allantoin. So the urine supernaturated with insoluble uric acid and it presented in two from in urine as uric acid and sodium urate which is more soluble than uric acid. Solubility depend on PH of urine, uric acid insoluble in acidic urine and soluble in alkaline urine, normally urine have low PH and impose with saturation with uric acid, lead to produce uric acid stones[10].
Uric acid stones patients might be have Gout and Myelo proliferative disorder.

1.6.3 Calicium phosphates stones:

With or without CO these stones form about 9% of renal calculi. Mostly occur with patients had renal tubular acidosis resulting from failure of kidney to acidify the urine due to defect of tubular H+ secretions which produce alkaline urine, these stat increase of saturation of urine with calcium and phosphates that end in stone formation [15].

1.6.4 Struvit stones

These form about 2-20 % of all stone types, which are consist from magnesium ammonium and phosphates. They form by action of bacteria that produce the ammonia from breakage of urea. Crystals of struvite will be precipitated if urine become alkaline [10].

1.6.5 Cystine stone:

About 2% from all types of stones, it happened commonly in patients with cystine uria (autosomal recessive). Patients manifested decrease in cystein absorption in GIT and renal tubular. Substance of cystein so insoluble, when the tubular in able to absorption lead to saturation of urine with cystein and end result formation of crystals [12].

1.6.6 Miscellaneous Stones:

a-Xanthine and Dihydroxyadenine stones are rare stones types. And they appear radiolucent similar to uric acid stone. These types produce due to inherited diseases of xanthine dehydrogenase enzymes. Result in xanthine accumulation and formation of xanthine stone [12].
b-Amonium acid urate stone represent less than 1% of all stones. In developing countries, however, endemic ammonium acid urate urolithiasis is still observed because it comprises bladder calculi in children.
c-Matrix stones: the association between urinary proteins and stone formation has long been recognized. Early experiments demonstrated that protein suspensions could promote calcium stone formation.

d-Drug induce renal stones are rare types of stones including ciprofluxacin, sulfa, triamterene and indinavir , most of these are radiolucent stones[13].

1.7 Clinical features

Features depend on size and location of stone. Small size stone might not cause any a symptom. Urinary bladder stone cause lower abdomen pain. Larger stone causes renal passage obstruction especially in ureter and renal pelvis, in addition to obstruction it causes variable degree of renal colic which is intermittent and severe pain. Patients are manifest pain commonly in back in lion region and radiate to anterior of abdomen and genital region. The pain have wave like intensity with gradual increase and then disappear in about one hour or less [16]. Patient has urgency and frequent urination. Additionally to that patients may be presented with nausea and vomiting, irritability and sweating. Occasionally, accompanied by heamaturia and piece of stone or stone in the urine. Fever and chills and other symptoms might be happened[17].

1.8 Diagnosis of renal stone

For diagnosis of renal stone we need a complete history and physical examination with specific tests such as blood investigation for certain substances calcium, phosphate, uric acid and electrolyte. Renal function test and analysis of urine for detection of crystals, blood, bacteria and stone piece if passed with urine[18].
Renal stone diagnosis start by history, clinical examination and laboratory and radiological investigation. Patients with renal colic highly suspect of renal stones. Tenderness in loin by physical examination or pain in genital region with out clear causes give hint of renal stone in addition to blood in urine, some times need more test to find the causes of pain [19].

1.8.1 Differential diagnosis of renal calculi

1- peritonitis
2- acute cholecystitis
3- bowel obstruction
4- pancreatitis
5- dissecting of aorta aneurysm
6- gynecological like ovarian torsion
7- diverticulitis

1.8.2 Investigation

Laboratory investigation include blood and urine tests. Urine analysis used for add a cue for diagnosis of stone. Every patients suspected to had calculi should be done for him urinalysis. Result of urinalysis include blood, pus, crystals(for knowing stone composition) and urine PH. Uric acid stone associated with low PH urine and in alkaline urine present stone due to infection [20].

1.9 Radiological investigation

Which include ultrasound examination, plain X-ray, MRI and CT scan[21].

1.9.1 Computed Tomography (CT)

CT scan the beneficial test for detection of renal stone. It have ability to reveal the stone location and precise assessment the degree of urinary tract obstruction by stone. More over it can detect other pathologies that cause the pain. But uses of CT scan expose the patient for high degree of radiation. But seem to be wise when probable other diagnosis such as aortic aneurysm dissecting[19]. The CT scan show the finding in Hounsfield unite (HU), which display the density of stone. First scientist discover of HU was Sir Godfrey Newbold Hounsfield to quantify the amount of radiate pass through the tissues or absorbed by body to reveal result of radiodensity score. Images from CT scan consist from pixel and every one has a gray scale value from one black to 257 white. These values equal to amount of x-ray which pass through the body that could be measure and display in Hounsfield unites. Therefore the HU used to assess the tissues and fluid. So the density by radiation of water is zero, fat has negative HU, while blood and body fluid have positive HU. Recently the Hounsfield unit can evaluate the renal stone to differentiate they by compositions and determine the suitable method of treatments[19]. The gold standard noninvasive test is non-enhance CT scan nowadays because it give detail information about stone size and location, presumptive effort for stone composition and predict of stone characters by Hounsfield unit with its standard deviation from region of interest [19].
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 and/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 [18]. Particularly when another type of examination, such as X-rays or physical examination, is not conclusive. 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 [19].

Ultrasonography;

It beneficial due to not need to exposure patients for radiation and used alternatively for CT scan. But U/S can missed the small size renal calculi and accurate location stone that cause the obstruction[19].

1.9.2 X-rays

Conventional x-rays of abdomen expose patients to lower dose of radiation, in turn these test are less accurate in detection of renal stone, it can only identify calcium stone. For this when physician suspect calcium stone type so x-ray preferred to study renal stone characters size and location[19].

Intravenous urography (IVU)

It perform by serial exposure the patient for X-ray after intravenous injection of radiopaque contrast. It well define the stone and precise location of stone. But need long time than other tests and have risk of allergy to contrast, now days rarely used for investigation renal stone[22].

1.10 Stone composition analysis

The benefit behind determine stone composition to manipulate mode of treatment. There were variable lines of management for patient have renal stone, knowing the type of stone limited the un necessary treatment and limited the time and cost. Patients advice by doctors to keep of piece of passed stone for analysis. Also there is addition investigation such as blood and urine test to identify substance that increase risk for stone formation[23].

In many study found a association between stone composition and Hounsfield unit of CT scan [22].

In extracorporeal shock wave lithotripsy is mandatory to identification stone composition because hardness of stone affects the outcome of treatment by ESWL.

In addition renal stone might be associated with systemic disease, for this knowing the composition give priority for treatment disease predisposing for formation [22].

Preventive plan become feasible when knowing the stone composition, for giving advice for patients and chemoprevention [24].

1.10.1 Renal stone prevention

Prevention measures varies according to many factors, in first degree stone composition. Recurrence rate also variable, 15% of patients that have renal stone for first time have chance for recurrence of passing stone in one year and double in five years [25]. General measure for all stone prevention is drinking of large amount of water and fluid. Other measures depend on stone types [26].

1.10.2 Calcium stone

Patients suffering from a stat of hypercalciuria frequent present accompanied by calcium stone. There is increase excretion of calcium in urine. For treatment of these patients, they should limited amount of calcium ingest in diet to decrease calcium in urine and prevent further stone formation. For example Diet high in potassium and low sodium[27].

1.10.3 Uric acid stone

The major cause stand behind uric acid stone is high acid level in urine. To treatment of this case should be administrated of potassium citrate to make urine alkaline and counterbalance the high acid in urine to prevent the stone formation. Other measure are limited animal protein in diet to reduce risk of uric acid stone formation, lastly intake large amount of fluid also helpful in treatment[26].

1.10.4 Cystine stone

Stone was formed due to high cystein level in urine , so should be maintain cystein level low by intake large amount of fuild, in addition to in some circumstances take mercaptopropionylglycine (tiopronin) or penicillamine[27].

1.10.5 Struvite stones

These type of stone is forming due infected of urinary tracts lead to recurrent stone passing. Treatment contain prescription of antibiotic for patients to treat urinary tract infection. Acetohydroxamic acid might be benifecial for management of struvit stone[23].

1.10.6 Treatment

Treatment strategy depends on stone size location and composition. Usually multiple patients recorded passing of stone or discover accidentally for investigation for other diseases. Small size stone which is not cause symptoms or could not obstruct the urinary tract or no infection might need any treatment.
While larger stone more than 5 mm and close to the kidney usually can not pas in their own and need treatment. Some time a number of medication give such tamsulosin and calcium channel blocker may elevated chance of spontaneous passing [13].

1.10.7 Pain relief

Commonly for reliving renal colic by non steroid analgesic can be used . but for severe pain potent analgesic such as opioids needed[18].

1.10.8 Stone-passing strategies

Drugs such alpha adrenergic blocker for example tamsulisin may be used to cause dilated of urinary tracts help in stone passing. Additionally intake of large quantity of fluid through drinking or intravenous administrating can also facilitate passing of stone[21].

1.10.9 Stone-bypass procedures

If severe obstruction due stone, we should stent to overcome the obstruction till stone removal procedures by surgery or other means. Stent place in special are by used the cystoscope [27].

1.10.10 Stone removal

Removal of stone depend on location and size determine the right approach open surgery or laser or ESWL. Stone in kidney and upper ureter 1cm in diameter usually treated by ESWL by destroy the stone to small piece to pass down with urine or by grasping by endoscope. Some time by laser lithotripsy [28].

1.11 Aim of study

Study the ability of nonenhanced CT scan in term of HU and HD parameters to predict the stone composition.

2. Patients and methods

2.1 Study design

A cross sectional study was enrolled patients suffering from renal stone that visited urological clinic in Babylon and Karbala teaching hospitals from 1st March to 1st August 2020.
Forty patients included in the study were referred to radiological department to investigation about stone characters (size, diameter and shape), patients that enrolled in study had single stone > 10 mm in diameter the diagnosis was made by urologist used ultrasound device they referred patient for KUB x-ray and non-enhanced CT scan. After extraction of stone by surgery or ESWL the stone send for laboratory to get chemical analysis by spectroscopy.

Exclusion criteria

1. Patients with renal stone of less than 10mm maximum diameter.
2. Patients with multiple renal stones (unilateral or bilateral).
3. Patients who didn’t collect their renal stones after treatment.

2.2 Data collection

Data recorded from patients according to questionnaire contain three parts first demography information (age, sex) and history and physical examination which was did by urologist in clinic. This part had detail history about diseases and pattern of pain, radiation, aggravating and relieving factors and hematurea if presented. Left or right effected kidney.

Second part about stone finding by radiological investigation by ultrasound, KUB and CT scan. Stone location, stone attenuation value (Hounsfield unit), Hounsfield first introduced the principle to quantify the amount of X-rays that pass through or are absorbed by tissues, and developed the resulting radiodensity scale. CT images are made up of pixels, each of which has a gray scale value from 1 (black) to 256 (white). This value corresponds to the amount of X-rays that pass through the structure, and can be measured and expressed in Hounsfield units (HU). HU have since been used to evaluate and quantify tissues and fluids. When the radiodensity of water is defined as 0, fat has a negative HU, and blood and other tissues have a positive HU. Using this method it is possible to differentiate 256 shades of gray that are indistinguishable to the naked eye[1]. Hounsfield density (HD) was recognized as HU/maximum transverse diameters of the stones (mm) and stones size measured in its maximum transverse diameters and HU of the stones (mean HU between two and five pixel point of the stones surface areas, depending on the stones area). In addition, the images saved in DICOM format.
Third part contain information about stone chemical analysis.

2.3 CT SCAN procedure

Non enhanced contrast CT scan was did in Siemens Somatom Perspective 128 slice CT-scanner (Siemens Health Global, Germany). For suspected cases of renal colic were undergone the CT scan with partially distended urinary bladder and without contrast. The test was did from upper abdomen at pole of kidney to pubic symphsis, the slice thickness of five millimeter follow by one millimeter thin rebuilding, coronal and sagital reformation by used three thickness section. The tubes potential were 100 – 130 KV and tubes current were 150-300 MA. The Hounsfield unit was standardized parameter to limited bias.
Regions of Interest (ROI) were draw by mark out the outline of the stones on the wedge with greatest diameters axially with the following parameters:
Windows level of 95 and windows width of 318 and magnification of 600%. Region of interest was draw inside one mm of margin of the stones to keep away from partial volume averaging. The predetermined software calculates the region, greatest, minimum and mean attenuation quantity of the stones and the reading was registered.

2.4 MDCT protocol

For diagnosis of stone is different from routine use abdominal and pelvis CT scan, from upper poles to base of urinary bladder. Five mm with reformat (3) mm to lower radial. In emergency there is different protocol to exclude stone diagnosis. Thinner slice of area same in abdominal and pelvis CT scan some time with contrast.

2.4.1 Exception for stones not seen in NECT:

1-pure matrix stone
2- indinavir stone (usually in IV composed of indinavir with other substance) because of soft tissues. Alternatively (15-30 HU) use of IV delay image.

2.4.2 Secondary signs of ureteric stone in CT:

1-perinephric fat stranding
2- periureteral edema
3- hydroureter or hydrnephrosis
-less constant signs: 1- perinephric edema 2- lateral malfusica thickening
- CT scan stone fragility: stone with internal homogeneity rigid and difficult to break by lithotripsy.
-Stone with inner heterogeneity (contain area of lower dense, high stone fragility.
-CT scan stone composition: uric acid stone suitable for medical treatment.
- Composition in vivo more reliable than in vitro due to :
1- Size area of interest .
2- slice thickness .
3- accurate placement ROI
4- Stone mixed of different material accurate is DECT (double energy CT scan)
- Reliable cut off value for composed stone in vitro.

2.5 Laboratory

All stone were analyzed and the major composition of the calculus was identified. The calculi then categories according to their composition.
Pure calcium oxalate, pure uric acid, pure struvite, mixed calcium oxalate CO + HXA, Mixed calcium oxalate (CO) + HXA + struvite (STR) and Mixed calcium oxalate CO + uric acid UA.
These stones classifications were based on the chief mineral content by stones analysis in range of 30% - 100%.

2.6 Ethical approval

Permission to conducted the study was obtains from health authorities. After clarify the objectives of study for patient/ relatives and take permission for including in this study, confidentiality and privacy was considered.

2.7 Statistical analysis:

Data was collected and included in a data based system and analyzed by statistical package of social sciences (SPSSversion20). Discrete variables presented as number and percentage, were analyzed using chi square. Continuous variables presented as mean ±SD (standard deviation). Significance was set at the $P \leq 0.05$ levels in all analyses.

Figure 2.1: Picture of CT SCAN device used in our study.

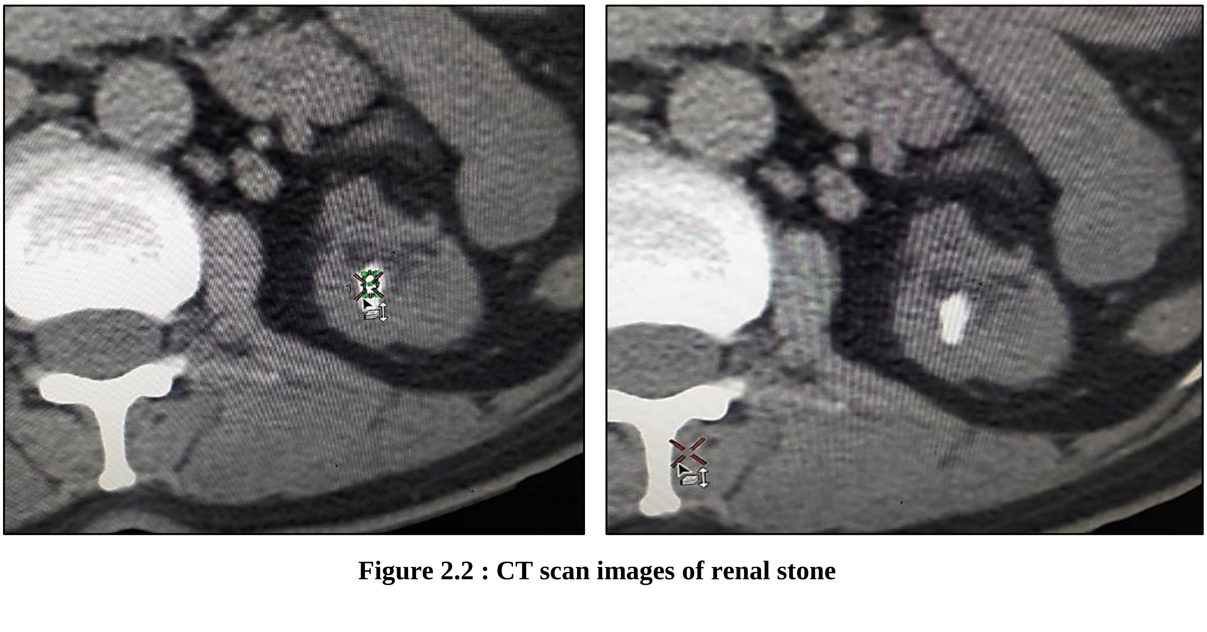

Figure 2.2 : CT scan images of renal stone

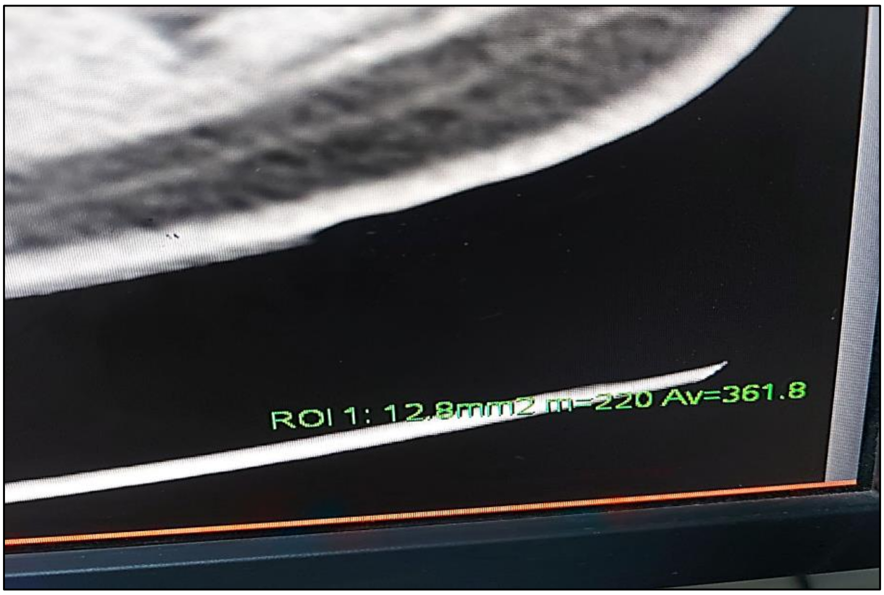

Figure 2.3: Show region of interest measurement of renal stone.

3. Result

The study was enrolled 40 patients with mean age 43.1±15.9, forty two percent of patients in age group 40-49 years, 15% in age group ≤30-39years 32.5% in age group 50-59 years and 10% only of them had age sixty and more as in shown table 3.1:

Male to female ratio 2.4:1, male constitute 73% and female 27% of sample. As seen in figure 3.1.

Table 3.1: The demographic characters of sample.

Demographic characters		No.	Percent
Age group	≤30-39years	6	**15%**
	40-49 years	17	**42.5%**
	50-59 years	13	**32.5%**
	≥60 years	4	**10%**
Total		**40**	
Gender	Male	29	**72.5%**
	Female	11	**27.5%**

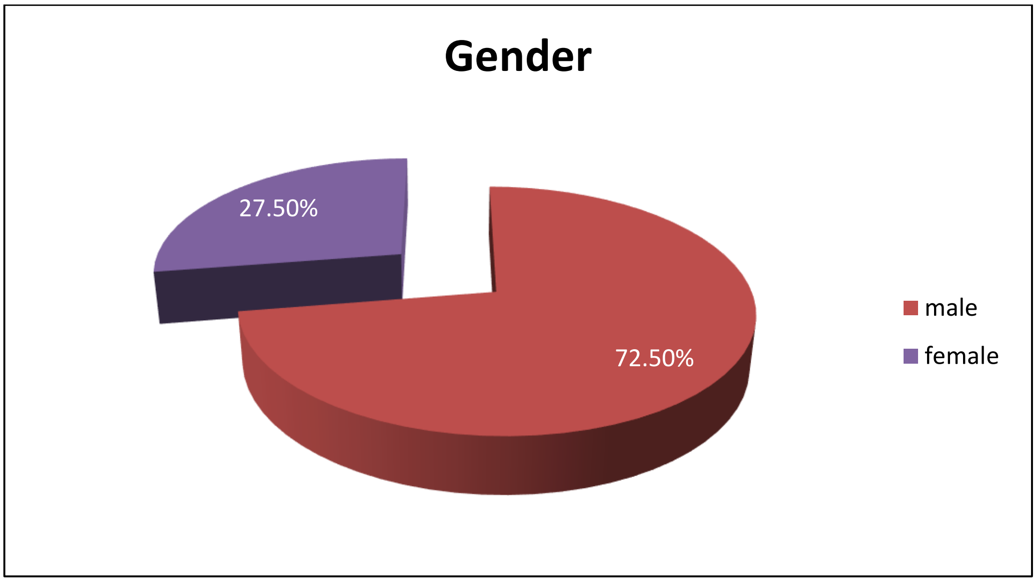

Figure 3.1 : Gender distribution.

According to laboratory analysis of stones, they were divided into six groups, pure calcium oxalate, pure uric acid, pure struvite, mixed CO + HXA, Mixed CO + HXA + STR and Mixed CO + UA. Pure CO stone more frequent were found in the study in 35%, 17.5% pure UA and 22.5% pure STR as shown in table 3.2.

Table 3.2 : Types of stones.

Stones types	No.	Percent
Pure CO	14	35%
Pure UA	7	17.5%
Pure STR	9	22.5%
Mixed CO + HXA	5	12.5%
Mixed CO + HXA + STR	2	5%
Mixed CO + UA	3	7.5%
Total	40	

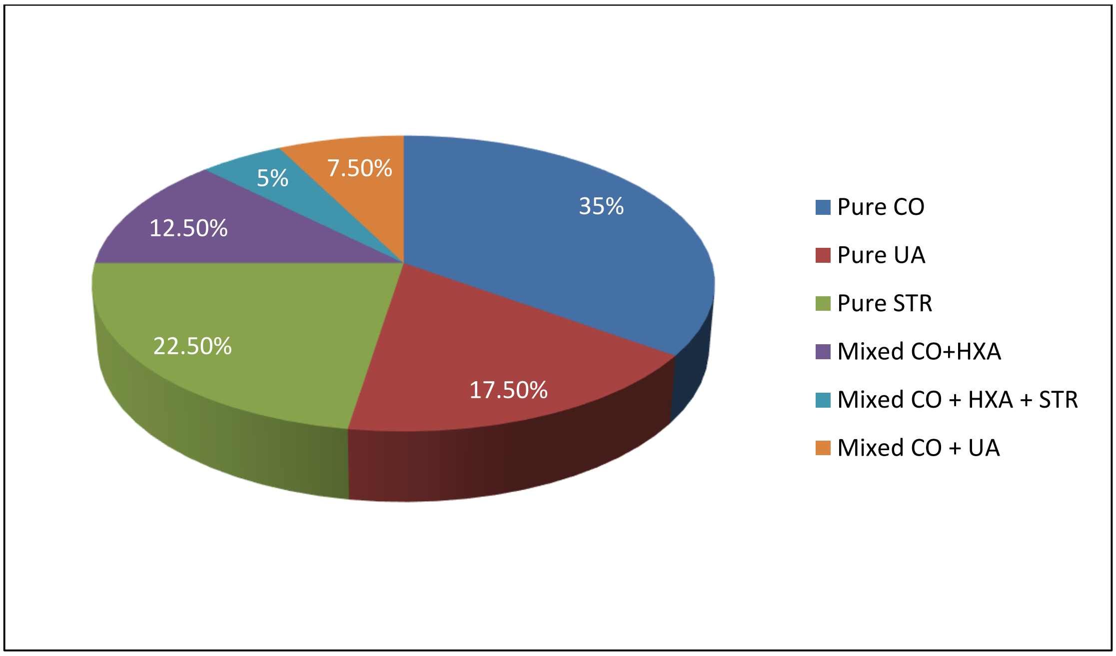

Figure 3.2: Show stones types.

In table 3.3 show the different values of Hounsfield units for variable types of stone ranging from 214- 1465, which presented significant relation between stones types and Hounsfield units. The mixed CO+HXA type of stone had more dense appearance 1280-1465 HU, the pure CO had density range from 1081- 1262 HU, the mixed CO+HXA+STR stone had 832-982 HU, the pure STR stone had 534- 733 HU, the mixed CO+UA stone had density range 395- 588 HU and the pure UA stones had density range from 214- 344 HU.

In regarding to the stone size, uric acid stone had the smallest size in mean 14.5±3.2 mm, on other hand mixed CO+ HXA stone had largest diameter of all types of stone in mean 29.4±2.9 mm, in overall estimation of stone size ranging 10-32 mm and mean 22. ± 10.3 mm. the difference between stone types in relation to diameter statistical not significant. As shown in table 3.3.

The Hounsfield density of stones ranging from 17-68.9 mm and mean 44.6±12.5mm. the highest Hounsfield density showed by CO stone in mean 58.3±9.2 mm. the pure uric acid had lowest HD mean 20.2± 1.9mm. There was significant relation between stone type and HD values. As in table 3.3.

Table 3.3 : Stones parameters according to types of stones.

Stones	Number	Percentage	Hounsfield units (mean± SD)	HD (mean± SD)	Stone diameter (mean± SD)
Pure CO	14	35%	1172.2±123.2	59.2±8.7	20.1±2.5
Pure UA	7	17.5%	298.3±80.5	20.1±2.4	14.8±3.9
Pure STR	9	22.5%	635.1±103.1	27.2±4.3	23.1±4.8
Mixed CO + HXA	5	12.5%	1365.3±98.2	46.2±3.8	29.3±3.2
Mixed CO + HXA + STR	2	5%	896.4±86.4	35.2±2.6	25.2±2.9
Mixed CO + UA	3	7.5%	503.2±72.3	24.1±1.9	20.4±3.1
P value			0.001	0.002	0.07

The comparison of stone diameter between male and female, we can see female had higher Hounsfield value and Hounsfield density in mean 973.2±356.1 and 45.3±15.6 respectively, there was statistically difference between gender, while stone diameter not show significance difference between gender in male the mean 21.2±4.5 and in female 21.8±5.3 mm. as shown in table 3.4.

Table 3.4 : comparison of stone parameter in related to gender.

Character	Male	Female	P-value
HU	462.7±786.2	356.1±973.2	**0.02**
HD	13.8±35.2	45.3±15.6	**0.01**
Stone diameter	4.5±21.2	5.3±21.8	**0.52**

There was significant difference in stone parameters and their appearance in X-ray of KUB plane. Twenty five percent of stone appear radiolucent and 75% show radiopaque character. Large size stone give radiopaque appearance and higher HU and HD value while smaller size stone appear radiolucent as shown in table 3.5 .

Table 3.5: Difference in parameter according to stone appearance in X ray.

Parameter	Radiopaque	Radiolucent	P-value
HU	364.8±987.3	76.1±324.2	**0.002**
HD	14.8±42.7	21.3±1.8	**0.001**
Stone diameter	3.9±23.2	2.5±15.8	**0.001**

The stone location statistically related to stone diameter, eighteen stones were located in pelvic part of kidney which were displayed larger size than other parts stones. Other stones located in middle, lower, and upper parts of kidney's patients. However no significant association between HU and HD parameter of stones and their location. As shown in table 3.6 .

Table 3.6: Difference in parameter of stone in related to stone location.

Stones location	No.	Hounsfield units (mean± SD)	HD (mean± SD)	Stone diameter (mean± SD)
Pelvic	18 (45%)	976.2±351.3	43.1±13.5	22.4±3.9
Lower calyx	9 (22.5%	822.1±386.3	39.2 ±16.3	19.9±5.3
Upper calyx	6 (15%)	645.2±461.2	34.1±15.6	17.5±6.4
Middle calyx	7 (17.5%)	699.2±374.5	29.4±13.2	21.4±5.3
P value		0.08	0.54	0.04

DISCUSSION :

Non enhance contrast CT scan easily and quickly achieved to patients even in un steady and renal failure patients. it supply huge data about stone in kidney and other urinary tracts, such as size, location and shape. The NCCT could be identifying all radiolucent calculi that overlook by other conventional radiological tests. The result of NCCT provide in Hounsfield unit for stone measurement which can be predicted the stones composition [28].

knowing the type of stone limited the un necessary treatment and limited the time and cost. Patient advice by doctors to keep of piece of passed stone for analysis. Also there is addition investigation such as blood and urine test to identify substance that increase risk for stone formation [23].

In many study found a association between stone composition and Hounsfield unit of CT scan [22].

Prediction of stone composition beneficial for patients management and to avoid diet that risk for stone formation [28].

Variable stone composition have different ways of treatment, for example calcium oxalate and cysteine stone are resistance to ESWL and percutaneous ultra sonic lithotripsy, while uric acid stone can be management by oral treatment for alkalinization of urine. Calcium oxalate di-hydrate and struvit stone degraded easily with ESWL [29] .

The mean age in our sample study was 43.1±15.9 with age range 20-72 years, 57.5% of them belong the group from 20-49 years, these result agree with Sharma, et al. study[30]. A study by Tanaka M et al., enroll patients with mean age was 56.3±11.8 years [31].

The age of selected patients in M.M. Dawoud et al study range from 25 to 66 year and mean age was 33± 10 years. The common age group affected belongs 30-40 year about 40% of sample [32].

Male to female ratio in our study was 2.4:1, male were constituted 73% and female were 27% of sample, which is consistent with other studies. Kamal Sharma presented 70% of the patients with stones were male[30].

On other hand Tanaka M et al., show men 61% and women 38%[31]. While Massoud AM presented men 60% and women 39% [33].

Gallioli et al study revealed close result about gender distribution, men 67% and women consist about 33% of sample, in addition the range age was from 14 -90 years[34].
Male was effected more than female these may be due hormonal variants between gender and deficient in stone inhibitors in male [30]. It is consider due to lithogenic activity of testosterone and lack of inhibition activity of estrogen hormone [10].
While a study by M.M. Dawoud et al study was stated renal stone more common in female (55%) than male (45%) [32].
Our result reveal variable kinds of stones, pure calcium oxalate, pure uric acid, pure struvite, mixed CO + HXA, Mixed CO + HXA + STR and Mixed CO + UA. Pure CO stone more frequent were found in the study in 35%, 17.5% pure UA and 22.5% pure STR. Which similar to result by Lee JS et al.,[35].
Gallioli et al show the stone composition in their study was classified the stone in four class as follow, calcium stone was 53%,uric acid was 34%, cystein was 8% and struvite was 6% [34].
M.M. Dawoud et al. they show the major types of calculi were calcium oxalate that constituent about 55% follow by cysteine 25% and uric acid were 20% [32].
The main result in this study, it presented significant relation between stones types and Hounsfield units. The mixed CO+HXA type of stone had more dense appearance 1280-1465 HU, the pure CO had density range from 1081- 1262 HU, the mixed CO+HXA+STR stone had 832-982 HU, the pure STR stone had 534- 733 HU, the mixed CO+UA stone had density range 395- 588 HU and the pure UA stones had density range from 214- 344 HU. Generally calcium containing stone had HU more than 1000. These result in consisted with Torricelli et al. study and their conclusion were Hounsfield unit of calcium oxalate stone appreciably high when compared to uric acid stone value in same study[36].
Andrea Gallioli stated that Hounsfield unit values are helpful if they initial offer discrimination of medium high (calcium, struvite) from low dense (uric acid, cystine) stone and then differentiate calcium from struvit stone. Hounsfield unit is the most excellent forecaster of stones density at a cut-off of 825 HU with a PPV of 93% and a NPV of 85.3%. also he had demonstrated that struvit had lower HU, that differentiate its from calcium with a more sensitivity (82.5%) and specificity (80%)[34].
M.M. Dawoud et al showed in his study, the uric acid stone range about (324–549) HU, while cystine stone had value about (1100–1700) HU whereas calcium oxalate stone has value of Hounsfield unit about (651–1800) HU[32].
Atici et al showed a calcium phosphate stone had a Hounsfield unit in mean about 1082 ± 412, while calcium oxalat stone had mean 850 ± 349 and struvit stone 447 ± 193. they were confirmed that calcium phosphate and struvit stone could be make a distinction on the base of their Hounsfield unit measurements[37].
Sotoodeh Shahnani, *et al* showed the calcium stone (HU 495-1250 mm) has the distinctive ranges of Hounsfield unit with no any overlaps when compared to another type of kidney calculi, they had Hounsfield unit HU more than 449 HU. In addition, It was establish that HD and HU can not predict for the precise compositions in cystin stone (HU 112-223), uric acid (HU 274-400), and struvit stone (HU 296-387) [38].
paradoxical conclusion have been available in the literatures relating to the capability of helical CT to exactly evaluate the chemical compositions of kidney stone. These variation could be clarified by the make use of the variable CT scanner, degree of collimation, energy setting, technique, stones size and perhaps reading of CT number. The method of CT scan play a role in measure the Hounsfield unit value of kidney stone, specially the size of collimation[37].
In present study, the Hounsfield density of stones ranging from 17-68.9 mm and mean 44.6±12.5mm. The highest Hounsfield density showed by CO stone in mean 58.3±9.2 mm. the pure uric acid had lowest HD mean 20.2± 1.9mm. there was significant relation between stone type and HD values. It agreed with study by Shahnani, PS et al who showed *a* strong relationship between the HD and the stone composition in 180 urinary stones from patients and reported that a association between compositions of stone and HU ($P = 0.001$), HD ($P < 0.0001$) were seen , the HD of CO were 49-68, STR stones HD were 20-38, while UA stones showed HD in range 23-41[38].
Our study demonstrated uric acid stone had the smallest size in mean 14.5±3.2 mm, on other hand mixed CO+ HXA stone had largest diameter of all types of stone in mean 29.4±2.9 mm, in overall estimation of stone size ranging 10-32 mm and mean 22. ± 10.3 mm. the difference between stone types in relation to diameter statistical not significant.
While Shahnani et al presented positive relation between stone size and stone composition [38]. Predicting the stone composition is very important for the urologists and way of treatment of renal stone, since many types of stones resist ESWL while ESWL monotherapy is more likely to be effective against other stones[39].
Nakasato T, reports that a renal stone of less than 815 HU easily treated with monotherapy ESWL than those with a higher HU [39].

Ouzaid I, evaluated 50 patients with urinary calculi of 5-22 mm undergoing ESWL, all patients had NCCT at 120 kV and 100 mA, they report that stone-free rate for stones of < 975 HU was 96% opposed to 38% for stone of ≥ 975 HU (P-value < 0.003) [40].

The table 4 in results shows significant difference in Hounsfield value and Hounsfield density between female and male. The female had higher value (HU 973.2±356.1 and HD 45.3±15.6) than male. This may due to lack of daily fluid intake more in female patients which agreed by Charles D [41].

There was significant difference in stone parameters and their appearance in X-ray of KUB plane. Twenty five percent of stone appear radiolucent and 75% show radiopaque character. Large size stone give radiopaque appearance and higher HU and HD value while smaller size stone appear radiolucent these result in consisted with Michael EC, that proposed cut-off value of 610 HU to differentiate between lucent and opaque stones[42]. In our result the lowest HU stones were UA and mixed CO + UA stone which appear radiolucent while other types appear radiopaque.

The stone location statically related to stone diameter, eighteen stones (45%) were located in pelvic part of kidney which were displayed larger size than other parts stones. Other stones located in middle (17.5%), lower (22.5%), and upper parts (15%) of kidney's patients. However, no considerable association between HU and HD parameter of stone and their location. These result near to study of Ouzaidi et al., they had been tested the site of nephrolithiasis, out of 50 patients, lower calyceal 9 (18%), Upper/mid calyceal 12 (24%) and renal pelvic/PUJ 29 (58%)(40) .

However, M.M. Dawoud et al. stated a ten calculi locate in ureter and forty calculi located in the kidney, five stones located at upper calyx, five calculi at middle calyx, twelve calculi located at lower calyx, ten calculi located at renal pelvis and eight calculi were staghorn stones filling renal pelvis[32].

Conclusion:

1- Non enhanced CT scan has been shown the effective way to prediction urinary stone composition with aid of measuring HU and HD of stone parameters.

2-There was no relation between types of stone and their diameters.

3- The study has been shown difference in stone parameter in according to stone appearance in X-ray radiopaque or radiolucent.

1-NCCT scan may be use to predict stone composition by measuring HU and HD.

2- HU and HD give an idea about the appearance of stone by KUB.

3- No relation between stone composition and stone border

Recommendation :

1- Urosurgeon can used of knowledge of stones composition in treatment plan depend on result of non-enhanced CT scan.

2- Can be determine of stones parameter HU and HD by non-enhanced CT scan

3-Using CT (HU and HD) to decided type and treatment of stone especially ESWL

Conflicts of interest :

There are no conflicts of interest.

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استخدام التصوير المقطعي المحوسب غير المعزز في توقع تكوين الحصى الكلوي

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الخلاصة

تُعرّف حصوات المسالك البولية بأنها كتلة صلبة في المسالك البولية وقد تسبب ألمًا نزيفًا او التهاب وفي بعض الأحيان تعيق تدفق البول. ترتبط هذه الأعراض بحجم الحصى وموقعه في المسالك البولية ، أصغرها لا تسبب أي أعراض ولكن الحصوات الكبيرة تظهر أحد الأعراض المذكورة أعلاه أو جميعها. وتعتمد علاج الحصوات المسالك البولية على تكوين الحصوات وهشاشتها. لذلك ، فإن معرفة تركيبة الحصى تحدد نهج العلاج والمسار المناسب لتخفيف المشكلة. بالإضافة إلى التحقق من تكوين الحاجة إلى التحليل المختبري. وقد تمثل هدف الدراسة في الكشف عن قدرة التصوير المقطعي المحوسب غير المعزز من حيث مؤشرات HU و HD للتنبؤ بتكوين الحصى اما طرق العمل فقد تم تسجيل دراسة مقطعية للمرضى الذين يعانون من حصوات الكلى الذين زاروا عيادة المسالك البولية في مستشفى بابل التعليمي ومستشفى كربلاء التعليمي من 1 يونيو إلى 1 سبتمبر 2020. وتم تضمين أربعين مريضًا وفحصهم حول علامات الحصوات (الحجم والقطر والشكل) ، وكان لدى المرضى حصوة واحد قطره أكبر من 10 مم ، وقد تم التشخيص من قبل طبيب المسالك البولية باستخدام جهاز الموجات فوق الصوتية الذي أحال المريض إلى الأشعة السينية KUB والأشعة المقطعية غير المحسنة. وفيما يخص النتائج فبعد ان تم تسجيل 40 مريضًا في الدراسة بمتوسط عمر 43.1 ± 15.9. كانت نسبة الذكور إلى الإناث 2,4: 1. حيث أظهرت الدراسة ست مجموعات من الحصوات ، أكسالات الكالسيوم النقي ، حمض البوليك النقي ، الستروفيت النقي ، أوكسالات الكالسيوم المختلط + HXA ، أوكسالات الكالسيوم المختلط + HXA + STR وأكسالات الكالسيوم المختلطة + UA. تم العثور على حجر أوكسالات الكالسيوم النقي أكثر تكرارا في الدراسة في 35٪ ، 17.5٪ UA نقي و 22.5٪ STR نقية. كانت هناك علاقة معنوية بين أنواع الأحجار ووحدات Hounsfield. بالإضافة إلى ذلك ، كانت هناك علاقة معنوية بين نوع الحجر وقيم كثافة Hounsfield. ومن اهم الاستنتاجات التي توصلنا اليها هو امكانية التصوير المقطعي المحوسب غير المعزز تحديد التركيب الكيميائي لمعظم أنواع الحصوات الكلوية عن طريق قياس وحدة Hounsfield وكثافة Hounsfield للحصوات.