# AIM OF THE WORK

The aim of the work was directed to correlate between Multidetector computed tomography radiodensity and determination of urinary tract stone composition.

# PATIENTS AND METHODS

The study was conducted on 100 patients with known urinary tract calculi, referred from the Genitourinary surgery outpatient clinic to the Department of Radiodiagnosis at Alexandria Main University Hospital for Multidetector computed tomography evaluation of urinary tract stone composition.

Inclusion criteria:

- Only one stone per each patient was included in the study.( i.e 100 patients = 100 stones).

Exclusion criteria:

- Patients with no detectable stones based on NCCT were excluded from the study.
- Stones less than 5mm were excluded from the study.

All the hundred stones were extracted using endurological techniques or open surgery and were subjected to chemical analysis.

The local ethics committee approved the study.

All patients included in the study were subjected to the following:

- **Complete history taking.**

- **Thorough Clinical examination.**

- **Non-enhanced Multidetector computed tomography**

The CT was performed using six detector multi-slices CT Somatome Emotion 6 (Siemens ,Germany)

**a. Patient preparation**

No specific patient preparation was requested except fasting for 6 hours before performing the procedure to avoid nausea and vomiting that might occur, no specific premedication was needed except for distended full urinary bladder.

**b. Patient position**

The patients laid down on the couch in the supine position, head first with the arms elevated above the head.

**c. Non contrast CT**

Initially a topogram was obtained in the antero-posterior view extending from lower chest down to upper thighs, with the patient lying supine, then the scans were performed by using a standard stone viewing protocol (breath holding technique at 120-140 kv, 79-260mA, series from the 11th thoracic vertebra to lower symphysis pubis was taken with a slice thickness 1.4-2.5mm range, a beam pitch 0.8 and a reconstruction increment of 1.25-1.75.

### d. Post processing

The conventional 2D axial images were viewed on a Siemens syngo workstation.
**Image analysis**

The image analysis of each scan was carried out in two separate evaluating sessions by two staff radiologists who were blinded to the chemical composition of the calculi.

Bone window (window width (WW) 1500 and the window level (WL) 300). The slice was magnified four fold, for each calculus, a region of interest was created overlying the calculus on the slice in which it was seen at its largest diameter.

For homogenous stones, the region of interest was created at the centre of the stone in which it was seen at its largest diameter, the Hounsfield unit was measured of an area 2 mm on average. For heterogeneous stone, the region of interest was created all over the stone in order to involve both high and low attenuation areas within the stone where it was seen at its largest diameter.

On the basis of these results, the maximum HU, the minimum HU and mean HU value were recorded.

Hounsfield unit density (HUD) was also calculated for each stone by taking the mean HU for each stone and dividing it by the largest transverse diameter of the stone.

Next, Maximum HU/size was calculated for each stone by taking the maximum HU for each stone and dividing it by the largest transverse diameter of the stone.

Hounsfield unit values were compared with the chemical composition of the stone.

## Stone analysis

All stones were analyzed at chemical pathology department at Institute of Medical Research, Alexandria University, Egypt. Stones composed of 97% or more of single component were considered pure.

## Statistical analysis [98]

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0.[99] Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. Comparison between different groups regarding categorical variables was tested using Chi-square test. When more than 20% of the cells have expected count less than 5, correction for chi-square was conducted using Fisher's Exact test or Monte Carlo correction. The distributions of quantitative variables were tested for normality using Kolmogorov-Smirnov test, Shapiro-Wilk test and D'Agstino test, also Histogram and QQ plot were used for vision test. If it reveals normal data distribution, parametric tests were applied. If the data were abnormally distributed, non-parametric tests were used. For abnormally distributed data, comparison between two independent population were done using Mann Whitney test. Significance of the obtained results was judged at the 5% level.

# RESULTS

The study was conducted on 100 patients with known urinary tract calculi, referred from to the Genitourinary surgery outpatient clinic to the Department of Radiodiagnosis at Alexandria Main University Hospital for Multidetector computed tomography evaluation of urinary tract stone composition.

- Only one stone per each patient was included in the study.( i.e 100 patients = 100 stones).
- Patients with no detectable stones based on NCCT were excluded from the study.
- Stones less than 5mm were excluded from the study.

All the hundred stones were extracted using endurological techniques  or open surgery and were subjected to chemical analysis.

The study population was a total of 100 patients, 80 men and 20 women ranging in age from 8-65years.

- ➢ The patients were distributed according to homogeneity of stones into two groups;
  1. Homogenous group represent 59% of cases, 49 males and 10 females ranging in age from 8-60 years with mean ±SD (36.3 ±13.9) and a median of 40 years.
  2. Heterogeneous group represent 41% of cases, 31 males and 10 females ranging in age from 23-65 years with mean ±SD (41.9 ±12.4) and a median of 45 years. (Tables 1, 2)

**Table (1): Distribution of studied cases according to homogeneity (n=100)**

|  | No. | % |
|---|---|---|
| **Homogeneity** |  |  |
| Homogenous | 59 | 59.0 |
| Heterogeneous | 41 | 41.0 |

**Table (2):  Distribution of studied cases according to demographic data**

|  | Homogenous (n=59) | | Heterogeneous (n=41) | | Test of sig. | p |
|---|---|---|---|---|---|---|
|  | No. | % | No. | % |  |  |
| **Sex** |  |  |  |  | $\chi^2=0.837$ | 0.360 |
| Male | 49 | 83.1 | 31 | 75.6 |  |  |
| Female | 10 | 16.9 | 10 | 24.4 |  |  |
| **Age** |  |  |  |  | $Z=1.622$ | 0.105 |
| Min. – Max. | 8.0 – 60.0 | | 23.0 – 65.0 | |  |  |
| Mean ± SD. | 36.32 ± 13.91 | | 41.93 ± 12.46 | |  |  |
| Median | 40.0 | | 45.0 | |  |  |

p: p value for comparing between the studied groups
$\chi^2$: Chi square test
Z: Z for Mann Whitney test

➢ Homogenous group shows higher mean HU values as compared with Heterogeneous group regarding;

1. Minimum HU(861.4±315.4 in homogeneous group, 486.2±201.3 in heterogeneous group)

2. Mean HU(1013.3±339.9 in homogeneous group, 689.6±305 in heterogeneous group)

3. Maximum HU(1148.8±406.7 in homogenous group, 881.7±442.6 in heterogeneous group)

4. HU Density(92.2±49.9 in homogeneous group,32.2±15.1 in heterogeneous group)

5. Maximum HU/size (104.8±54.3 in homogeneous group,40.1±18.2 in heterogeneous group) (Tables 3,5).

**Table (3): Distribution of studied cases according to Hounsfield (HU) value**

| HU | Homogenous (n=59) | Heterogeneous (n=41) | Z | p |
|---|---|---|---|---|
| **Maximum** | | | | |
| Min. – Max. | 444.0 – 1787.0 | 335.0 - 1482.0 | | |
| Mean ± SD. | 1148.83 ± 406.76 | 881.76 ± 442.69 | 2.620[*] | 0.009[*] |
| Median | 1238.0 | 661.0 | | |
| **Minimum** | | | | |
| Min. – Max. | 385.0 – 1363.0 | 204.0 – 881.0 | | |
| Mean ± SD. | 861.46 ± 315.47 | 486.24 ± 201.33 | 5.740[*] | <0.001[*] |
| Median | 878.0 | 441.0 | | |
| **Mean** | | | | |
| Min. – Max. | 418.0 – 1476.0 | 263.0 – 1179.0 | | |
| Mean ± SD. | 1013.34 ± 339.90 | 689.66 ± 305.03 | 4.485[*] | <0.001[*] |
| Median | 1037.0 | 623.0 | | |

Z: Z for Mann Whitney test

*: Statistically significant at $p \leq 0.05$

The stone size according to maximum transverse diameter ranged from 7 to 37 mm (mean 14.7) in homogenous group and 10 to 30 mm (mean 22.6) in heterogeneous group (Table 4).

**Table (4): Distribution of studied cases according to maximum transverse diameter**

| | Homogenous (n=59) | Heterogeneous (n=41) | Z | p |
|---|---|---|---|---|
| **Max. transverse diameter control (mm)** | | | | |
| Min. – Max. | 7.0 – 37.0 | 10.0 – 30.0 | | |
| Mean ± SD. | 14.78 ± 9.60 | 22.68 ± 6.59 | 4.938[*] | <0.001[*] |
| Median | 10.0 | 23.0 | | |

Z: Z for Mann Whitney test

*: Statistically significant at $p \leq 0.05$

Hounsfield unit density (HUD) was calculated for each stone by taking the mean HU for each stone and dividing it by the largest transverse diameter of the stone.

Next, Maximum HU/size was calculated for each stone by taking the maximum HU for each stone and dividing it by the largest transverse diameter of the stone.

**Table (5): Distribution of studied cases according to HU density and Maximum HU/ size**

| | Homogenous (n=59) | Heterogeneous (n=41) | Z | p |
|---|---|---|---|---|
| **HU density** | | | | |
| Min. – Max. | 11.0 – 170.0 | 16.0 – 62.0 | | |
| Mean ± SD. | 92.27 ± 49.96 | 32.24 ± 15.13 | 5.664[*] | <0.001[*] |
| Median | 105.0 | 26.0 | | |
| **Max. HU/ size** | | | | |
| Min. – Max. | 12.0 – 178.70 | 18.0 – 66.10 | | |
| Mean ± SD. | 104.87 ± 54.36 | 40.17 ± 18.24 | 5.495[*] | <0.001[*] |
| Median | 113.67 | 46.40 | | |

Z: Z for Mann Whitney test

*: Statistically significant at $p \leq 0.05$

Stone analysis revealed 46 urate, 33 calcium, 6 cystine and 15 calcium phosphate urate stones in total cases.

The homogeneous group revealed 18 urate, 26 calcium, 6 cystine and 9 calcium phosphate urate stones. While the heterogeneous group revealed 28 urate, 7 calcium, and 6 calcium phosphate urate stones.

No significant difference was noted between the HU values of calcium oxalate and calcium phosphate stones, and thus they were analyzed collectively as "calcium stones." (Table 6)

**Table (6): Distribution of studied cases according to chemical stone analysis**

| | Total (n=100) | | Homogenous (n=59) | | Heterogeneous (n=41) | | $\chi^2$ | $^{MC}p$ |
|---|---|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % | | |
| **Stone analysis** | | | | | | | | |
| Urate stone | 46 | 46.0 | 18 | 39.1 | 28 | 60.9 | | |
| Calcium | 33 | 33.0 | 26 | 78.8 | 7 | 21.2 | 16.961* | 0.001* |
| Cystine | 6 | 6.0 | 6 | 100.0 | 0 | 0.0 | | |
| Calacium phosphate urate stone | 15 | 15.0 | 9 | 60.0 | 6 | 40.0 | | |

$\chi^2$: value for Chi square
MC: Monte Carlo test
*: Statistically significant at $p \leq 0.05$

We found that 89 of the stones were located in the kidney, 7 in ureter, and 4 in urinary bladder where 78 stones were located in the left kidney and 11 in the right kidney, distributed as following 36 in the renal pelvis, 15 in upper calyx, 16 in middle calyx, 22 in lower calyx (Table 7).All of the 7 ureteric stones were located in right ureter, 4 in upper third, 3 in lower third (Table 8).

**Table (7): Distribution of studied cases according to their site within the kidney**

| | Homogenous (n=59) | | Heterogeneous (n=41) | | $\chi^2$ | p |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | | |
| **Site kidney** | | | | | | |
| Right | 4 | 8.3 | 7 | 17.1 | 1.559 | 0.212 |
| Left | 44 | 91.7 | 34 | 82.9 | | |
| Renal pelvis | 18 | 30.5 | 18 | 43.9 | | |
| Upper calyx | 12 | 20.3 | 3 | 7.3 | 5.063 | 0.167 |
| Middle calyx | 8 | 13.6 | 8 | 19.5 | | |
| Lower calyx | 10 | 16.9 | 12 | 29.3 | | |

$\chi^2$: Chi square test
*: Statistically significant at $p \leq 0.05$

**Table (8): Distribution of studied cases according to their site within ureter**

| Right | | | Left | | |
|---|---|---|---|---|---|
| Upper third | Middle | Lower third | Upper third | Middle | Lower third |
| **4** | **0** | **3** | **0** | **0** | **0** |

4 out of 100 of our patients had urinary bladder stones. All of them were homogenous.

## *I. Statistical analysis of Minimum HU*

➢ Minimum HU was compared with  stone types:

1. In homogeneous group as well as in total cases

    Significant differences were noted between Min HU values of:

    Uric acid and calcium stones,

    Uric acid and cystine stones,

    Uric acid and mixed stones.

2. In heterogeneous group

    The overlap of Min HU values prevented accurate identification of the chemical type of the stones; it was statistically insignificant among different stone types. (Table 9)

**Table (9):  Relation between Stone analysis and minimum HU in each studied group and total cases**

| Minimum HU | Stone analysis | | | | $^{KW}\chi^2$ | p |
|---|---|---|---|---|---|---|
| | Urate stone (I) | Calcium (II) | Cystine (III) | Calacium phosphate urate stone (IV) | | |
| **Homogenous** | **N=18** | **N=26** | **N=6** | **N=9** | | |
| Min. | 385.0 | 654.0 | 798.0 | 656.0 | | |
| Max. | 727.0 | 1309.0 | 878.0 | 1363.0 | | |
| Mean | 511.89 | 1036.50 | 838.0 | 1070.0 | 33.939*** | <0.001*** |
| SD. | 123.04 | 214.18 | 43.82 | 347.38 | | |
| Median | 467.0 | 1037.0 | 838.0 | 1350.0 | | |
| **Sig. bet. grps.** | I-II***, I-III***, I-IV***, II-III** | | | | | |
| **Heterogenous** | **N=28** | **N=7** | | **N=6** | | |
| Min. | 204.0 | 225.0 | - | 288.0 | | |
| Max. | 881.0 | 693.0 | - | 663.0 | | |
| Mean | 487.0 | 492.43 | - | 475.50 | 0.205 | 0.902 |
| SD. | 195.70 | 250.16 | - | 205.40 | | |
| Median | 441.0 | 693.0 | - | 475.50 | | |
| **Sig. bet. grps.** | - | | | | | |
| **Total cases** | **N=46** | **N=33** | **N=6** | **N=10** | | |
| Min. | 204.0 | 225.0 | 798.0 | 288.0 | | |
| Max. | 881.0 | 1309.0 | 878.0 | 878.0 | | |
| Mean | 496.74 | 921.09 | 838.0 | 569.90 | 35.781*** | <0.001*** |
| SD. | 169.85 | 313.99 | 43.82 | 205.90 | | |
| Median | 464.0 | 1004.0 | 838.0 | 656.0 | | |
| **Sig. bet. grps.** | I-II***, I-III***, I-IV** | | | | | |

p: p value for comparing between Stone analysis categories

$\chi^2$: Chi square for Kruskal Wallis test

Sig. bet. grps was done using Mann Whitney test

*: Statistically significant at $p \le 0.05$

**: Statistically significant at $p \le 0.01$

***: Statistically significant at $p \le 0.001$

## II. Statistical analysis of Mean HU

➢ Mean was compared with stone types:

1. In homogeneous group as well as in total cases

   Significant differences were noted between Mean HU values of:

   Uric acid and calcium stones,

   Uric acid and cystine stones,

   Uric acid and mixed stones.

2. In heterogeneous group

   *Less overlap* was noted when comparing Mean HU values of stones; it was statistically significant among different stone types. (Table 10)

**Table (10): Relation between Stone analysis and Mean HU in each studied group and total cases**

| Mean HU | Stone analysis | | | | $^{KW}\chi^2$ | p |
|---|---|---|---|---|---|---|
| | Urate stone (I) | Calcium (II) | Cystine (III) | Calacium phosphate urate stone (IV) | | |
| **Homogenous** | **N=18** | **N=26** | **N=6** | **N=9** | | |
| Min. | 418.0 | 1009.0 | 837.0 | 1037.0 | | |
| Max. | 928.0 | 1476.0 | 1391.0 | 1427.0 | | |
| Mean | 594.39 | 1185.42 | 1114.0 | 1287.0 | 36.837[***] | <0.001[***] |
| SD. | 188.76 | 165.89 | 303.44 | 187.97 | | |
| Median | 505.0 | 1161.0 | 1114.0 | 1400.0 | | |
| **Sig. bet. grps.** | I-II[***], I-III[**], I-IV[***], III-IV[*] | | | | | |
| **Heterogenous** | **N=28** | **N=7** | | **N=6** | | |
| Min. | 263.0 | 479.0 | - | 788.0 | | |
| Max. | 1173.0 | 1179.0 | - | 877.0 | | |
| Mean | 611.71 | 879.0 | - | 832.50 | 7.599[*] | 0.022[*] |
| SD. | 293.54 | 374.17 | - | 48.75 | | |
| Median | 493.0 | 1179.0 | - | 832.50 | | |
| **Sig. bet. grps.** | I-II[*], I-IV[*] | | | | | |
| **Total cases** | **N=46** | **N=33** | **N=6** | **N=10** | | |
| Min. | 263.0 | 479.0 | 837.0 | 788.0 | | |
| Max. | 1173.0 | 1476.0 | 1391.0 | 1427.0 | | |
| Mean | 604.93 | 1120.42 | 1114.0 | 1105.20 | 45.819[***] | <0.001[***] |
| SD. | 255.40 | 252.85 | 303.44 | 272.32 | | |
| Median | 505.0 | 1161.0 | 1114.0 | 1037.0 | | |
| **Sig. bet. grps.** | I-II[***], I-III[**], I-IV[***] | | | | | |

p: p value for comparing between Stone analysis categories
$\chi^2$: Chi square for Kruskal Wallis test
Sig. bet. grps was done using Mann Whitney test
*: Statistically significant at $p \leq 0.05$
**: Statistically significant at $p \leq 0.01$
***: Statistically significant at $p \leq 0.001$

No calcium based stone had a Mean HU less than 1000 HU and no urate stone had a Mean HU greater than 1000 HU in homogenous group. (Table 11)

**Table (11):  Distribution of studied cases in homogenous group according to Mean HU cut off value of 1000**

| | Stone analysis | | | |
|---|---|---|---|---|
| | **Urate stone** | **Calcium** | **Cystine** | **Calacium phosphate urate stone** |
| **Mean HU** | | | | |
| <1000 | 18 | 0 | 3 | 0 |
| >1000 | 0 | 26 | 3 | 9 |

### III. Statistical analysis of Maximum HU

➢ Maximum HU was compared with  stone types:

1.  In homogeneous group as well as in total cases

Significant differences were noted between Maximum HU values of:

Uric acid and calcium stones,

Uric acid and cystine stones,

Uric acid and mixed stones.

2.  In heterogeneous group

***Less overlap*** was also noted when comparing Maximum HU values of stones; it was statistically significant among different stone types. (Table 12)

**Table (12): Relation between Stone analysis and maximum HU in each studied group and total cases**

| Maximum HU | Urate stone (I) | Calcium (II) | Cystine (III) | Calacium phosphate urate stone (IV) | $^{KW}\chi^2$ | p |
|---|---|---|---|---|---|---|
| **Homogenous** | **N=18** | **N=26** | **N=6** | **N=9** | | |
| Min. | 444.0 | 1023.0 | 884.0 | 1319.0 | | |
| Max. | 1568.0 | 1616.0 | 1787.0 | 1787.0 | | |
| Mean | 770.83 | 1263.96 | 1335.5 | 1447.78 | 18.268*** | <0.001*** |
| SD. | 443.01 | 194.08 | 494.59 | 143.81 | | |
| Median | 533.0 | 1238.0 | 1335.5 | 1450.0 | | |
| **Sig. bet. grps.** | I-II***, I-III**, I-IV*, II-IV** | | | | | |
| **Heterogenous** | **N=28** | **N=7** | | **N=6** | | |
| Min. | 335.0 | 642.0 | - | 1146.0 | | |
| Max. | 1413.0 | 1482.0 | - | 1392.0 | | |
| Mean | 738.71 | 1122.0 | - | 1269.0 | 9.647** | 0.008** |
| SD. | 415.53 | 449.0 | - | 134.74 | | |
| Median | 539.0 | 1482.0 | - | 1269.0 | | |
| **Sig. bet. grps.** | I-II*, I-IV* | | | | | |
| **Total cases** | **N=46** | **N=33** | **N=6** | **N=15** | | |
| Min. | 335.0 | 642.0 | 884.0 | 1146.0 | | |
| Max. | 1568.0 | 1616.0 | 1787.0 | 1787.0 | | |
| Mean | 751.28 | 1233.85 | 1335.50 | 1376.27 | 31.288*** | <0.001*** |
| SD. | 421.89 | 265.90 | 494.59 | 162.85 | | |
| Median | 539.0 | 1238.0 | 1335.50 | 1392.0 | | |
| **Sig. bet. grps.** | I-II***, I-III**, I-IV*** | | | | | |

p: p value for comparing between Stone analysis categories
$\chi^2$: Chi square for Kruskal Wallis test
Sig. bet. grps was done using Mann Whitney test
*: Statistically significant at $p \le 0.05$
**: Statistically significant at $p \le 0.01$
***: Statistically significant at $p \le 0.001$

No calcium based stone had Maximum HU less than 1000 HU while few urate stones had Maximum HU greater than 1000 in homogenous group. (Table 13)

**Table (13):** **Distribution of studied cases in homogenous group according to Maximum HU cut off value of 1000**

| | Stone analysis | | | |
|---|---|---|---|---|
| | **Urate stone** | **Calcium** | **Cystine** | **Calacium phosphate urate stone** |
| **Maximum HU** | | | | |
| <1000 | 14 | 0 | 3 | 0 |
| >1000 | 4 | 26 | 3 | 9 |

## *IV. Statistical analysis of HU density*

➤ HU density (HUD) was compared with stone types:

1.  In homogenous group as well as in total cases, highly significant differences were noted between HU density of :

    Uric acid   and calcium stones,

    Uric acid   and cystine stones,

    Uric acid   and mixed stones.

2.  In heterogeneous group, No significant difference was noted among different stone types. (Table 1 4)

**Table (14): Relation between Stone analysis and HU density in each studied group and total cases**

| HU density | Stone analysis | | | | $^{KW}\chi^2$ | p |
|---|---|---|---|---|---|---|
| | **Urate stone (I)** | **Calcium (II)** | **Cystine (III)** | **Calacium phosphate urate stone (IV)** | | |
| **Homogenous** | **N=18** | **N=26** | **N=6** | **N=9** | | |
| Min. | 11.0 | 105.0 | 83.0 | 39.60 | | |
| Max. | 69.0 | 170.0 | 139.0 | 139.0 | | |
| Mean | 36.61 | 133.54 | 111.0 | 71.87 | 41.042*** | <0.001*** |
| SD. | 21.93 | 23.20 | 30.67 | 39.64 | | |
| Median | 26.00 | 129.00 | 111.0 | 40.0 | | |
| **Sig. bet. grps.** | I-II***, I-III***, I-IV*, II-IV*** | | | | | |
| **Heterogenous** | **N=28** | **N=7** | | **N=6** | | |
| Min. | 16.0 | 22.0 | - | 26.0 | | |
| Max. | 62.0 | 42.0 | | 38.0 | | |
| Mean | 32.0 | 33.43 | - | 32.0 | 2.341 | 0.310 |
| SD. | 17.48 | 10.69 | | 6.57 | | |
| Median | 21.0 | 42.0 | - | 32.0 | | |
| **Total cases** | **N=46** | **N=33** | **N=6** | **N=15** | | |
| Min. | 11.0 | 22.0 | 83.0 | 26.0 | | |
| Max. | 69.0 | 170.0 | 139.0 | 139.0 | | |
| Mean | 33.80 | 112.30 | 111.0 | 55.92 | 50.116*** | <0.001*** |
| SD. | 19.24 | 46.57 | 30.67 | 36.36 | | |
| Median | 26.0 | 118.0 | 111.0 | 39.60 | | |
| **Sig. bet. grps.** | I-II***, I-III***, I-IV*, II-IV***, III-IV* | | | | | |

p: p value for comparing between Stone analysis categories

$\chi^2$: Chi square for Kruskal Wallis test

Sig. bet. grps was done using Mann Whitney test

*: Statistically significant at $p \leq 0.05$

**: Statistically significant at $p \leq 0.01$

***: Statistically significant at $p \leq 0.001$

## *V. Statistical analysis of Maximum HU/size*

➢ Max. HU/size was compared with stone types:

1. In homogenous group as well as total cases, highly significant differences were noted between Max. HU/size of

   uric acid and calcium stones,

   uric acid and cystine stones,

   uric acid and mixed stones.

2. In heterogeneous group, No significant difference was noted among different stone types. (Table 15)

**Table (15): Relation between Stone analysis and Maximum HU/size in each studied group and total cases**

| Max. HU /size | Stone analysis | | | | $_{KW}\chi^2$ | p |
|---|---|---|---|---|---|---|
| | **Urate stone (I)** | **Calcium (II)** | **Cystine (III)** | **Calacium phosphate urate stone (IV)** | | |
| **Homogenous** | **N=18** | **N=26** | **N=6** | **N=9** | | |
| Min. | 12.0 | 113.67 | 88.40 | 40.60 | | |
| Max. | 82.50 | 178.30 | 178.70 | 178.70 | | |
| Mean | 47.36 | 142.60 | 133.55 | 91.78 | 35.259*** | <0.001*** |
| SD. | 31.62 | 25.57 | 49.46 | 53.37 | | |
| Median | 27.80 | 137.60 | 133.55 | 88.40 | | |
| **Sig. bet. grps.** | I-II***, I-III***, I-IV*, II-IV* | | | | | |
| **Heterogenous** | **N=28** | **N=7** | | **N=6** | | |
| Min. | 18.0 | 22.10 | - | 46.40 | | |
| Max. | 66.10 | 52.90 | - | 49.80 | | |
| Mean | 38.59 | 39.70 | - | 48.10 | 0.763 | 0.683 |
| SD. | 20.39 | 16.46 | - | 1.86 | | |
| Median | 27.90 | 52.90 | - | 48.10 | | |
| **Total cases** | **N=46** | **N=33** | **N=6** | **N=15** | | |
| Min. | 12.0 | 22.10 | 88.40 | 46.40 | | |
| Max. | 82.50 | 178.30 | 178.70 | 178.70 | | |
| Mean | 42.02 | 120.77 | 133.55 | 74.31 | 46.111*** | <0.001*** |
| SD. | 25.41 | 48.85 | 49.46 | 46.04 | | |
| Median | 27.90 | 126.30 | 133.55 | 49.80 | | |
| **Sig. bet. grps.** | I-II***, I-III***, I-IV*, II-IV**, III-IV* | | | | | |

p: p value for comparing between Stone analysis categories
$\chi^2$: Chi square for Kruskal Wallis test
Sig. bet. grps was done using Mann Whitney test
*: Statistically significant at p ≤ 0.05
**: Statistically significant at p ≤ 0.01
***: Statistically significant at p ≤ 0.001

A cut off value 80 for HU density in homogeneous group revealed that all urate stones (n=18) had HU density less than 80.All calcium stones (n=26) as well as all cystine stones (n=6) had HU density greater than 80 (Table 16).

A cut off value 80 for HU density in total cases revealed that all urate stones (n=46) had HU density less than 80.All cystine stones (n=6) had HU density greater than 80 (Table 16).

**Table (16):    Distribution of studied cases according to HU density (HUD) cut off value of 80 in homogeneous group and total cases.**

| HU density | Stone analysis | | | |
|---|---|---|---|---|
| | **Urate stone** | **Calcium** | **Cystine** | **Calacium phosphate urate stone** |
| **Homogenous** | | | | |
| <80 | 18 | 0 | 0 | 5 |
| >80 | 0 | 26 | 6 | 4 |
| **Total cases** | | | | |
| <80 | 46 | 7 | 0 | 11 |
| >80 | 0 | 26 | 6 | 4 |

A cut off value 85 for Max.HU/size in homogeneous group revealed that all urate stones (n=18) had Max. HU/size less than 85.All calcium stones (n=26) as well as all cystine stones (n=6) had Max HU/size greater than 85 (Table 17).

A cut off value 85 for Max.HU/size in total cases revealed that all urate stones (n=46) had Max. HU/size less than 85.All cystine stones (n=6) had Max. HU/size greater than 85  (Table 17).

**Table (17):    Distribution of studied cases according to Max HU/size cut off value of 85 in homogeneous group and total cases.**

| HU maximum/size | Stone analysis | | | |
|---|---|---|---|---|
| | **Urate stone** | **Calcium** | **Cystine** | **Calacium phosphate urate stone** |
| **Homogenous** | | | | |
| <85 | 18 | 0 | 0 | 4 |
| >85 | 0 | 26 | 6 | 5 |
| **Total cases** | | | | |
| <85 | 46 | 7 | 0 | 10 |
| >85 | 0 | 26 | 6 | 5 |

# Case I
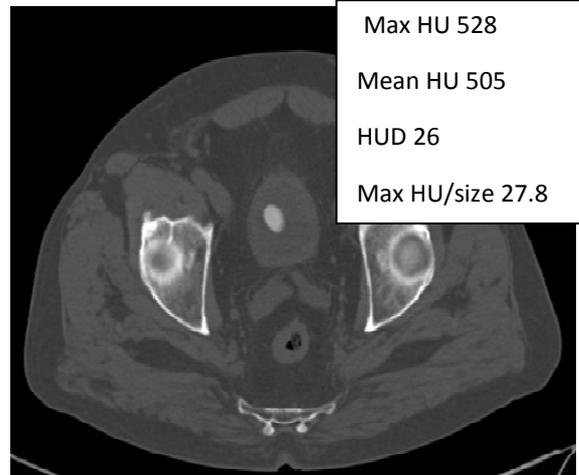


(a)                                              (b)

60-years –old male with urinary bladder homogeneous uric acid stone   (a) axial CT scan (soft tissue window settings [400/60]   (b) axial CT scan (bone window settings [1500/300] shows Max HU (528), Mean HU (505), HUD(26), Max HU/ size(27.8).
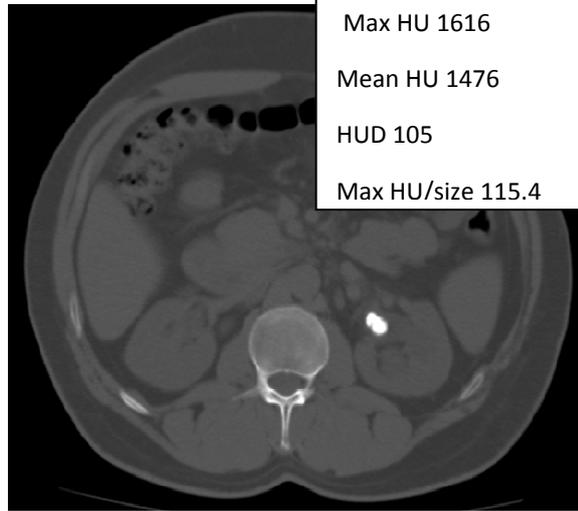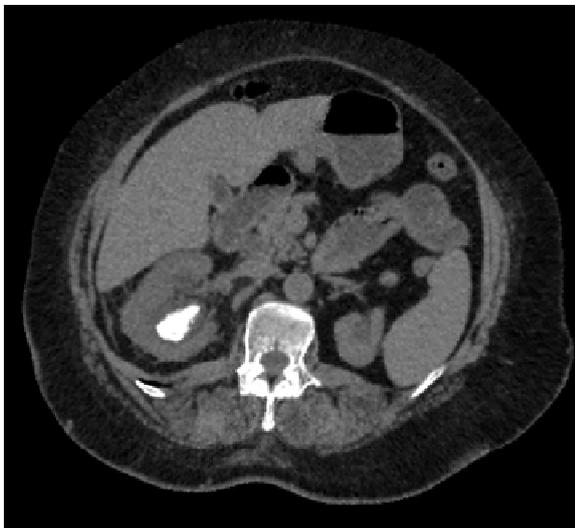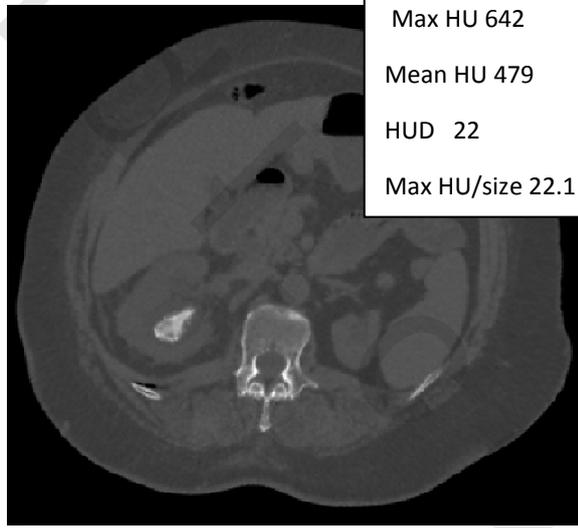
# Case II
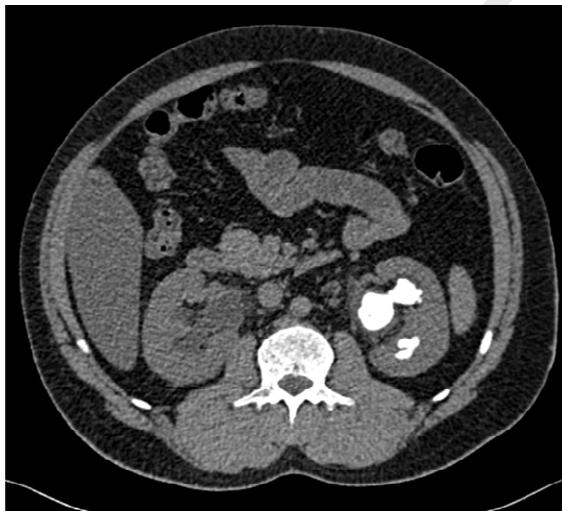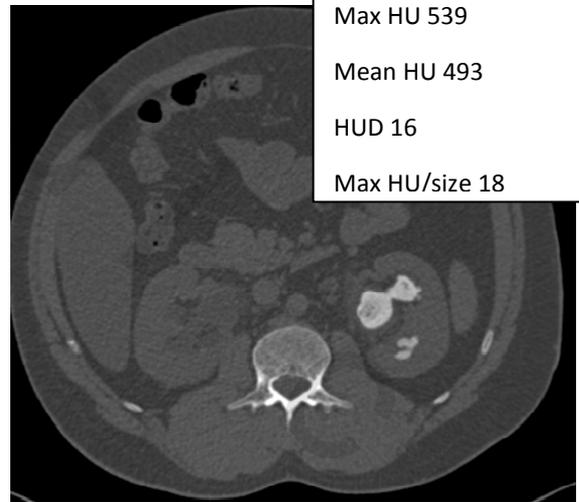


(a)                                              (b)

30-years –old male with left staghorn heterogeneous uric acid stone   (a) axial CT scan (soft tissue window settings [400/60]   (b) axial CT scan (bone window settings [1500/300] shows Max HU (539), Mean HU (493) , HUD(16), Max HU/ size(18).

# Case III
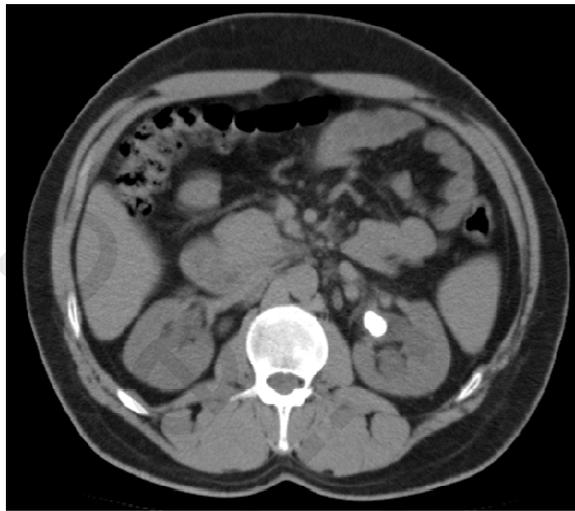


(a)                              (b)

45-years –old  male with left renal pelvis  homogeneous  calcium oxalate stone   (a) axial CT scan (soft tissue window settings [400/60]   (b) axial  CT scan (bone window settings [1500/300] shows Max HU (1616), Mean HU (1476) , HUD (105), Max HU/ size (115.4).
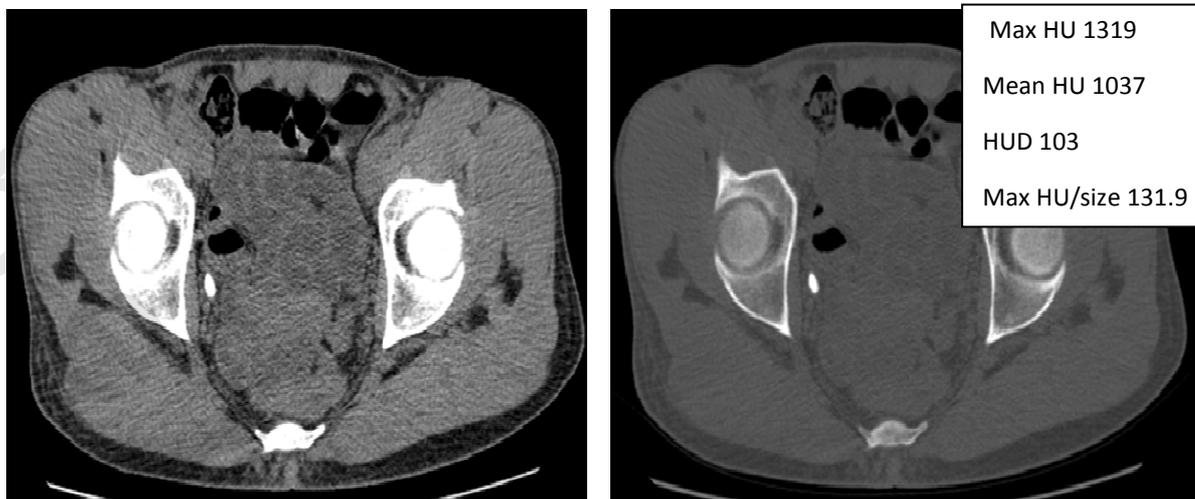
# Case IV



(a)                              (b)

50-years –old female with right upper calyceal heterogeneous calcium phosphate stone (a) axial CT scan (soft tissue window settings [400/60]   (b) axial CT scan (bone window settings [1500/300] shows Max HU (642), Mean HU (479) , HUD (22), Max HU/ size (22.1).
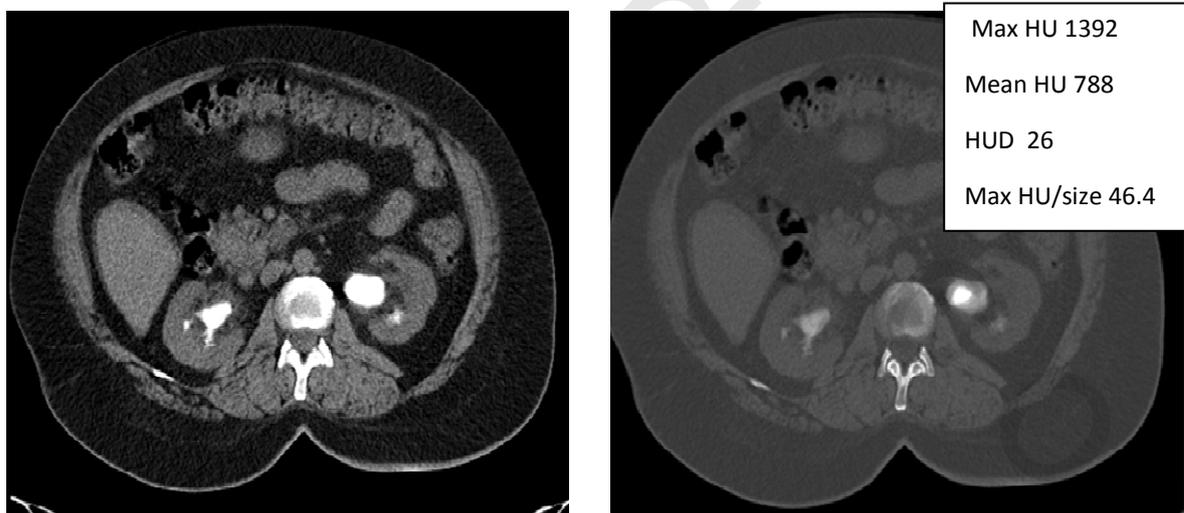
## Case V



(a)                                    (b)

36-years –old male with homogeneous  calcium phosphate-urate stone in lower third of right ureter  (a) axial CT scan (soft tissue window settings [400/60]    (b) axial CT scan (bone window settings [1500/300] shows Max HU (1319), Mean HU (1037) , HUD (103), Max HU/ size (131.9).

## Case VI


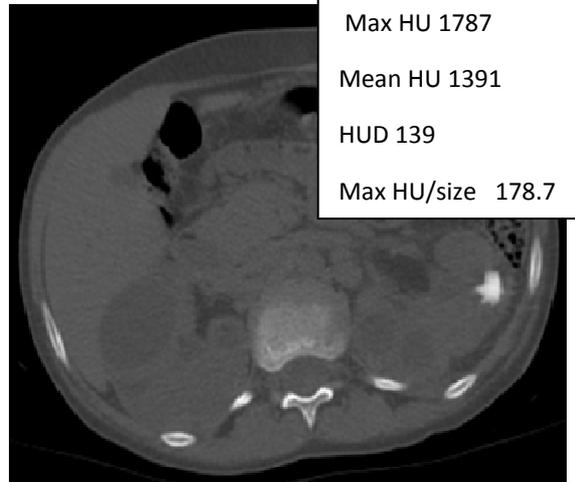
(a)                                    (b)

Bilateral renal pelvic stones in 60-years –old male with left staghorn heterogeneous calcium phosphate-urate stone      (a) axial CT scan (soft tissue window settings [400/60] (b) axial CT scan (bone window settings [1500/300] shows Max HU (1392), Mean HU (788) , HUD (26), Max HU/ size (46.4).

# Case VII



(a)           (b)

8-years –old child with left middle calyceal homogenous cystine stone (a) axial CT scan (soft tissue window settings [400/60]   (b) axial CT scan (bone window settings [1500/300] shows Max HU (1787), Mean HU ( 1391) , HUD (139), Max HU/ size (178.7).