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CHEMICAL ANALYSIS OF URINARY TRACT CALCULI BY DUAL SOURCE CT IN ARAVALI HILLY AREA

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ABSTRACT:

Objective: To qualitatively analyze the uroliths in vivo using dual source CT by crystallography as the reference standard in Udaipur, an Aravalli Hilly area located in southern region of Rajasthan (India) so as to evaluate the predominant constituent present in them and report its significance. **Materials and Methods:** The study was conducted in Radiology department of Pacific Medical College & hospital, Udaipur on 25 patients of all age group (4 to 70 years) with clinical suspicion or known/ suspected calculi on X-ray or USG. The 128 slice Somatom definition dual source CT was used to analyse chemical composition of renal, ureteric and vesicle stones. **Results:** Of the 25 patients studied, 13 were males and 12 females. 22 patients (88%) had oxalate stones, 2(8%) had uric acid stones and 1(4%) had mixed calculus of oxalate and hydroxyapatite. There were total 48 calculi of which 30 were in kidneys (62.5%), 14 in ureters (29.2%) and 4 in urinary bladder (8.3%) of these 25 patients. 12 patients had single calculus and 13 had multiple calculi. The CT density for calcium oxalate stones was around & more than 1000 HU, for uric acid stones around 500 HU to 600 HU and for the mixed stone 876 HU. **Conclusion:** The study reveals significantly high incidence of calcium oxalate stones in Aravali hilly areas which may be due to altered eating and drinking habits which promoted its formation in these individuals. The MDCT without dual source was accurate in classifying urinary stone composition. Randomized clinical trials should be encouraged for validating this technique on large populations.This may help the health care providers to look through the risk factors for calculi formation in this area which might enable them to plan therapies and prevent recurrence of stone formation.

Key Words: Urolithiasis, dual source CT, chemical composition.

INTRODUCTION:

Urinary stones (Urolithiasis) are the consequence of crystallization and aggregation of highly concentrated urinary components. It is a common reason of outpatient visits and hospitalization. Moreover, the risk of its recurrence even after treatment is about 50% in 10 years (1). The clinical presentation could be an occasional abdominal pain or even renal failure which is independent of the stone size (2). The epidemiology of urolithiasis differs in accordance with the geographical area which is on account of difference in race, diet and climatic factors. Furthermore changing socio-economic conditions affects lithiasis in terms of both the site and the chemical-physical composition of the calculi.

Urolithiasis as a multifactorial disease which is distributed worldwide in urban, rural, non industrial and industrial regions with different chemical composition of analyzed stones in context to etiological and risk factors. The majority (75–85%) of stones are made of calcium, but 2–15% are struvite, while uric acid stones account for 6–10% and cystine stones 1–2%. In USA the most common stone composition is calcium oxalate (40–60%), followed by uric acid (5–10%), hydroxyapatite (2–4%), and cystine (1–3%) (1). The most common type of kidney stone seen in the UK is calcium-containing – usually calcium oxalate or a mixture of calcium oxalate and calcium phosphate (3).

In India calcium oxalate is the most common stone and much more frequent than USA and European countries, particularly in Aravali hilly tribal areas, where there is poor population and poor resources. Most of the people there are still dependent on the hard ground water for the drinking use so the incidence of calcium oxalate stones is significantly high. The ideal level of hardness should be 50-150mg/L. Softening of water is recommended when hardness exceeds 3mEq/L (300mgper liter) (4).

The MDCT without dual source is more precise than IVU for detection of urinary tract stones as it can give information of even a millimeter sized calculus, but effort made to chemically analyse the stone only on the basis of density do not give appreciable results (5). The dual energy acquisition with syngo CT DE Calculi Characterization software allowed not only a precise localization of stones but also gave more accurate information of its chemical composition which is helpful in choice of approach of treatment (6). Dual source CT is a new technology that employs two different x-ray sources that provide an image resolution that has not been possible with conventional single source CT (7).

The present study was aimed to qualitatively analyze the uroliths in vivo using dual source CT by crystallography as the reference standard in Udaipur, an Aravalli Hilly area located in southern region of Rajasthan (India) so as to evaluate the predominant constituent present in them and report its significance.

MATERIALS AND METHODS

The study was conducted in Radiology department of Pacific Medical College & hospital, Udaipur, which covered the population of adjacent hilly areas.

Twenty five patients of all age group (4 to 70 years) with clinical suspicion or known/ suspected calculi on X-ray or USG were included for study. Out of 25 patients, 13 patients were male and 12 patients were females. Informed consent was obtained from the patients after the institutional ethical clearance for the study.

The 128 slice Somatom definition dual source CT by siemens at our institution is capable of analysing chemical composition of renal, ureteric and vesicle stones by syngo CT DE Calculi Characterization software with almost same accuracy with actual chemical analysis by crystallography. Knowledge about chemical composition guides the choice of appropriate treatment approach.

All patients underwent plain CT KUB for urinary tract evaluation using a dual-energy technique with parameters for tube 1 (MAS=85; voltage 140 KV) and for tube 2 (MAS= 468; voltage 80 KV). The pitch for the study was 0.7 with 5mm slice thickness which reconstructed at 1.5mm. 3D reconstruction was done for each study. Acquisition was 14 x 1.2 mm and rotation time 0.5sec. The images were post processed on dedicated syngo via remote work station with DE Calculi Characterization software.

Average attenuation values in Hounsfield units were calculated for the two energy levels, and the ratio between the average low-energy attenuation and the average high-energy attenuation was derived, then this ratio for each stone was projected on a graph of four stone types (calcium oxalate, hydroxyapatite, cystine and uric acid) where lower part contains non calcium stones (hydroxyapatite, cystine, and uric acid) with lower most line refers to uric acid stones and upper part contains calcium stones (calcium oxalate). If density and attenuation ratios of calculus lies in upper part of graph the calculus is automatically painted blue and if density and attenuation ratios of calculus lies in lower part of graph the calculus is painted red. Determination of calculus composition can be made according to the position of calculus on graph in relation to the values of calcium oxalate, hydroxyapatite, cystine, and uric acid calculi.

RESULTS

A total of 25 patients were studied of which 13 were males and 12 females. Out of 25 patients, 22 patients (88%) had oxalate stones, 2 patients (8%) had uric acid stones and 1 patient (4%) had mixed calculus of oxalate and hydroxyapatite.

There were total 48 calculi in kidneys, bladder and ureters of 25 patients. 12 patients had single calculus and 13 had multiple calculi. Out of 48 calculi, the percentage of distribution with respect to location was as-30 calculi were in kidneys (62.5%), 14 in ureters (29.2%) and 4 in urinary bladder (8.3%). One calculus in right kidney was Staghorn calculus. Percentage was calculated according total number of stones which showed that oxalate stones were 93.75%, uric acid stones 4.17% and mixed stone were 2.08%.On analysis, only two calculi were found to be formed by uric acid composition and one was found formed by mixed oxalate and hydroxyapatite composition. Rest 45 calculi were formed by calcium oxalate. Stone diameter varied from 2 mm to 28 mm sized (two < 2mm sized calculi were discarded from study, as FOI cannot be selected for Calculi Characterization). The CT density for calcium oxalate stones was around & more than 1000 HU, for uric acid stones around 500 HU to 600 HU and for the mixed stone 876 HU.

Along with chemical composition of stone we also observed the site, size and CT density of the stones.

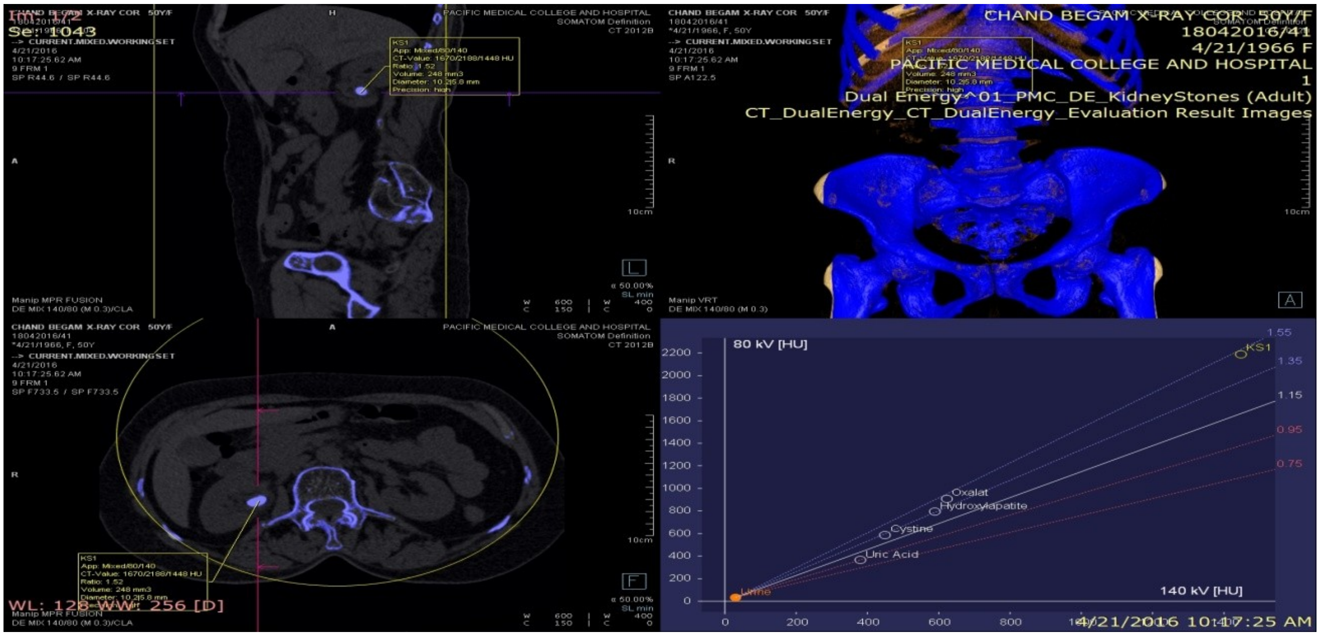

Fig.1 Shows Above images are elaborated with Calculi characterization software by siemens, including three views of stone in sagittal, axial planes and 3D in coronal plane with graphic presentation. In diagram, graphs of four stone types (calcium oxalate, hydroxyapatite, cystine, and uric acid) are described by four small circles According to their increased attenuation ratios (CT density at 140 kVp on x-axis and CT density at 80 kVp on y-axis).. Lower part contains noncalcium stones (hydroxyapatite, cystine, and uric acid) with lower most line refers to uric acid stones and upper part contains calcium stones (calcium oxalate). This is the case of 50 year old male having a calculus of 11mm sizes in the right renal pelvis. The calculus shown in three views is automatically painted blue by software as its CT density lies in upper part of graph (in graph the circle of calculus KS1 showing density of around 2000 and average attenuation ratio 1.5, lying upper most part of graph). These software findings are suggestive of calcium oxalate calculus.

DISCUSSION

Level of hardness of water varies from place to place in this Aravali region but was found to be higher than the acceptable level. In a study conducted by B.K. Sharma and L.L. Sharma (2008) the hardness of water in Udaipur district was reported to be 150-500 mg/L, in Banswara 274-276 mg/L, and in Dungarpur 270-290 mg/L (8).

Most of the regions of the area we studied the subjects from also had high fluoride. The prevalence of urolithiasis was 4.6 times higher in EA than in NEA. Furthermore, the prevalence was almost double in subjects with fluorosis than without fluorosis in the endemic area (9, 10).

High and progressively increasing incidence of urolithiasis in Udaipur and some other parts of Rajasthan have been reported by Pendse et al (11).

Urolithiasis can be found in any part of the urinary system of either sexes. Our study reported a predominance suffered by males, located mostly in the kidneys, with mostly oxalate as the chemical composition. The types of stones formed depend mainly on the composition of urine, which in turn is governed by the kind of diet consumed in the areas. Our study was in tune with Ansari et al who analysed 1050 stones (900 renal, 150 ureteric) and found 977 (93%) were composed of calcium oxalate. Only small percentage contain of uric acid 10.95%) struvite 1.4% apatite 1.8%.

It is important to know the chemical composition of stones so as to be able to plan therapies and prevent recurrences. The risk of recurrence for calcium oxalate stones is 10% after an year and 50% at 10 years after treatment (8). These therapies might eliminate the need for extracorporeal shock wave lithotripsy, a procedure that is expensive and subject to complications (12,13,14).

CONCLUSION

The study reveals significantly high incidence of calcium oxalate stones (88% of all patients and 93.75% stones of total kinds of stones) in Aravali hilly areas which may be due to altered eating and drinking habits which promoted it's formation in these individuals. The MDCT without dual source was accurate in classifying urinary stone composition. Randomized clinical trials should be encouraged for validating this technique on large populations. The collected information in this regard may help to look through the risk factors for calculi formation in this area which might enable the health care providers for deciding surgical / non surgical approach for treatment and also will help them to decide strategy for prevention of recurrence of stone formation in them.

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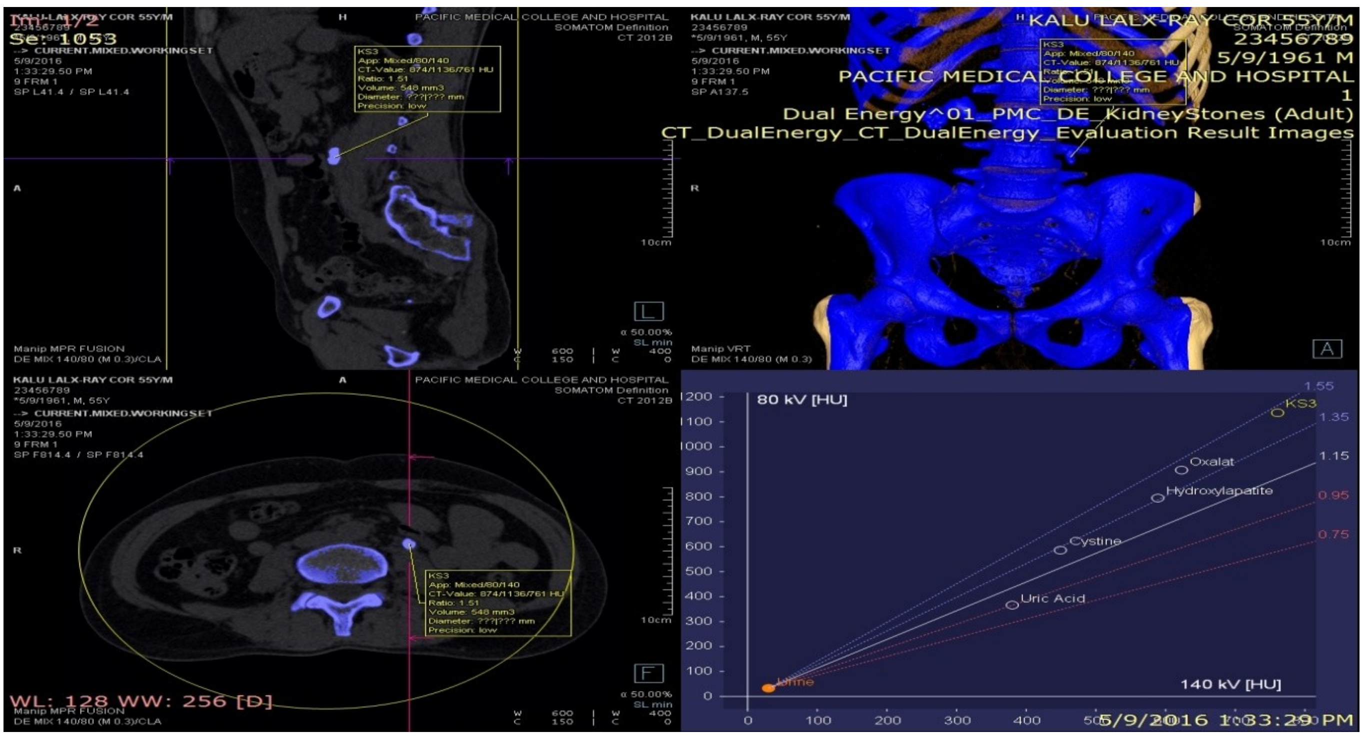

Fig.2 This is the case of 55 year old male having a staghorn calculus of 26mm size in the right renal pelvis with 6 small calculus in right inferior calyces and one calculus of 8mm sized in middle calyx of left kidney along with left upper ureteric calculus of 17mm size and resultant left hydroureteronephrosis. The ureteric calculus shown in three views is automatically painted blue by software as its CT density lies in upper part of graph (in graph the circle of calculus KS3 showing density of around 1100 and average attenuation ratio 1.5, lying upper most part of graph). These software findings are suggestive of calcium oxalate calculus.

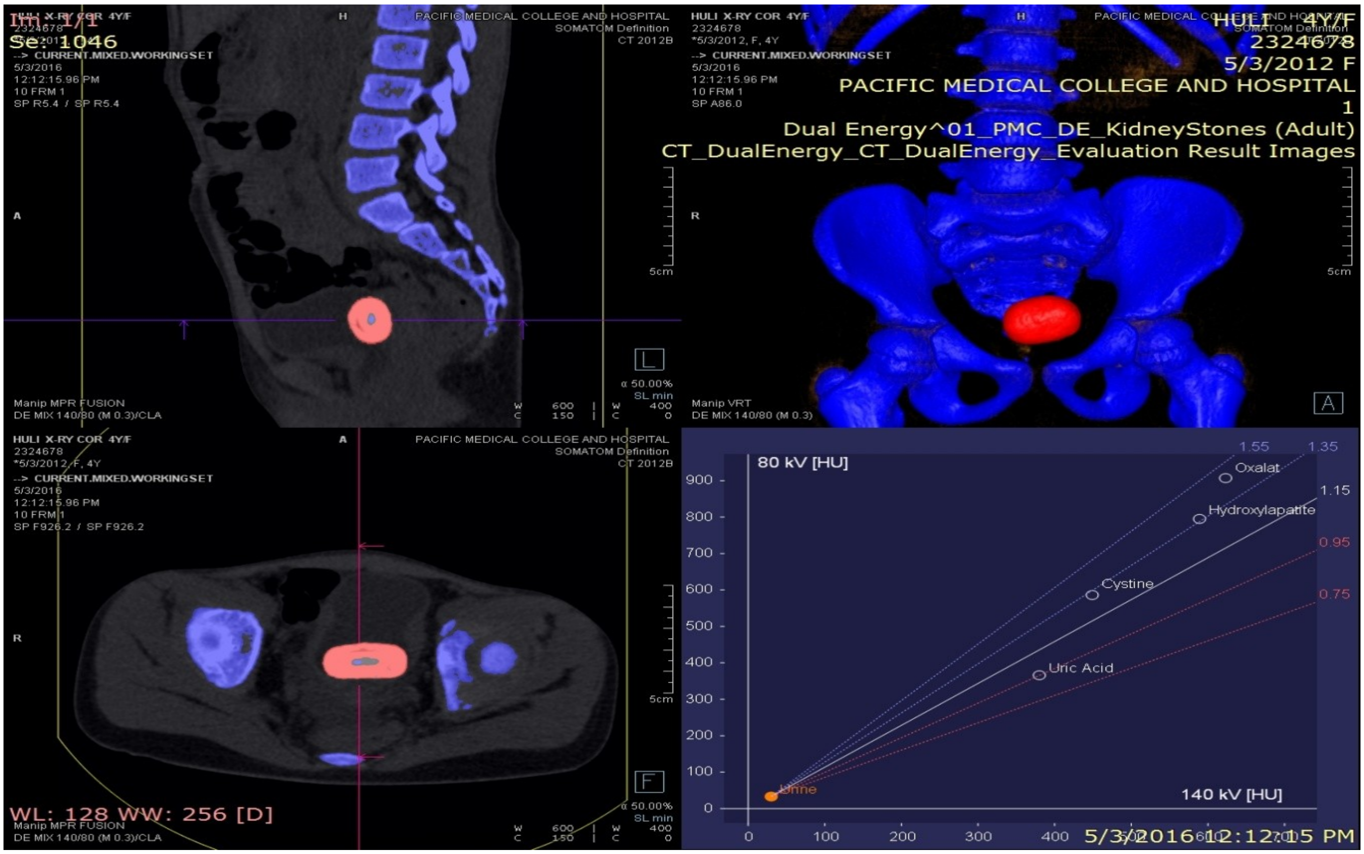

Fig.3 Elaborated images with calculi characterization software by siemens, including three views of stone in sagittal, axial planes and 3D in coronal plane with graphic presentation. This is the case of 4 year female child having a large urinary bladder calculus of 29mm with average CT density of 527 HU. The calculus in three views is automatically painted red by software as its CT density and attenuation ratios lies in lower part of graph. These software findings are suggestive of uric acid stone.