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To determine the chemical composition of urinary stones retrieved after surgical procedures in patients at Indira Gandhi Medical College and Hospital, Shimla

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Abstract

Background: The chemical compositions of urinary stones include crystals and non crystalline phases or the organic material (the matrix). The organic matrix of urinary stones consists of macromolecules such as glycosaminoglycans (GAG's), lipids, carbohydrates and proteins.

Methods: The study was conducted over a period of one year from July 2017 to June 2018 in urolithiasis patients admitted in the Department of General Surgery and Urology at IGMC Shimla.

Results: Maximum calculi (n=51) showed calcium oxalate monohydrate (CaOMH) of 60-80% as one of the constituents having mean CT attenuation of 1091.74±162.2 HU. Calculi comprising of calcium oxalate dihydrate (CaODH) (<20%) as one of the constituents was found in 64 patients with mean CT attenuation of 1005.1±193.1 HU. Matrix was found as a composition in all samples retrieved. Majority (n=73) of the samples had less than (<) 5% composition with mean CT attenuation value of 1032.5±171.2 HU. 7 patients each had mixed type of calcium phosphate and uric acid stone with mean CT attenuation of 842.85±136.7 HU and 907.14±212.9 HU respectively. In 2 patients carbonate apatite stone composition was seen which had mean CT attenuation value of 1000±353.5 HU.

Conclusion: In the present study, chemical composition of the urolithiasis by FTIR method showed mixed type of calculus. None of the stones were pure. Maximum stones had mixed calcium oxalate crystals. Phosphate, uric acid and carbonate apatite crystals were other type of composition which were present in the study samples. They were also found in combination with matrix, thus rendering them impure.

Keywords: Calcium Oxalate Crystals, Uric Acid, Carbonate.

Introduction

The chemical compositions of urinary stones include crystals and non crystalline phases or the organic material (the matrix). The organic matrix of urinary stones consists of macromolecules such as glycosaminoglycans (GAG's), lipids, carbohydrates and proteins. These molecules play a significant role by promoting or inhibiting the processes of kidney stone development. The main components of the stone matrix are proteins (64%), non amino sugars (9.6%), hexosamine as glucosamine (5%), water (10%), and inorganic ash (10.4%). The matrix acts as a template participating in the assembly of kidney stones. The matrix of all stones contains phospholipids (8.6%) of the total lipid, which in turn represents about 10.3% of stone matrix. Cell membrane phospholipids, as part of organic matrix, promote the formation of calcium oxalate and calcium phosphate stones[18]. Albumin is the major component of the matrix of all stone types[1].

Imaging is a vital cog in the wheel of diagnosis and management of patients suspected with renal and ureteric calculi and it is imperative to choose the appropriate investigation that is accurate and safe for the patient. The choice of appropriate investigation depends on various factors such as the nature of presentation, body habitus of the patient, cost of the investigation and the effect of the investigation on the patient. Many modalities are available for investigating stone in patients such as ultrasonography (USG), X-ray, computed tomography (CT) scan and magnetic resonance imaging (MRI). CT, USG and X-ray are used widely. USG has lesser sensitivity when compared with CT for diagnosing renal stones.

Non-contrast computerized tomography (NCCT) is currently the gold standard for diagnosing nephrolithiasis with a sensitivity and specificity of 94%–97% and 96%–100%, respectively, when compared with USG which has a sensitivity of 60% and a specificity of 84% and plain abdominal radiography or intravenous urography which has a sensitivity and specificity of 45%–58% and 52%–87%, respectively[2]. NCCT has got some advantages over USG, that it is not influenced by the body habitus and the accuracy is not interfered by bowel gas. Almost all the stones except some matrix stones and indinavir stones can be detected by NCCT accurately with reliable size measurements with the error in stone size being around 3.6%[3]. The main disadvantages of NCCT are that it is costly and also has a risk of radiation exposure, the cumulative effects of which is hazardous and has also been found to lead to malignancy later.

Material and methods

From July 2017 to June 2018 indoor patients of urolithiasis admitted in Department of Surgery and Urology IGMC were enrolled for the present study**.** Urolithiasis patients after complete urological and radiological workup were subjected for OSS/ Laparoscopic procedure/ PCNL/ URSL/ ESWL according to patient and stone profile for clearance of urinary stone**.**

Exclusion Criteria

The following patients were excluded from the study :

- Pregnant female patients with urolithiasis**.**
- Patients with bleeding diathesis**.**

Preop evaluation of patient was done and it included -

Complete blood investigations like CHG, RBS, RFT, Serum electrolytes, PT/INR, BT/CT

Urine examinations like

Urine R/E (albumin and sugar)

Urine M/E & Urine C/S.

UPT in female patients of reproductive age group

- Plain X-Ray KUB after bowel preparation
- USG KUB
- NCCT KUB
- IVU/CT-Urography

Non-Contrast Computed Tomography **(**NCCT)

NCCT KUB of all patients was performed on a 64 slice CT scanner **(**Model**:** VCT Xte;GE Healthcare**).**Patient were made to lie supine on the table and images were acquired in craniocaudal direction from the upper pole of kidney to symphysis pubis. The protocol for NCCT KUB consisted of following parameters.

Statistical Analysis: The data collected was transferred into MS excel spread sheet for further analysis and processing. Descriptive data was expressed in the form of frequency and percentage. Continuous variables were presented in term of mean and standard deviation.

Results

The Study was conducted from July 2017 to June 2018.We enrolled total of 100 patients. who met the inclusion criteria and those who consented to participate in the study.

Table 1: NCCT HU (Hounsfield Units) of different stones

S.No	**NCCT-HU**	**Frequency**	**%age**
0	<650	4	4.00%
1	650-850	15	15.00%
2	850-1050	34	34.00%
3	1050-1250	40	40.00%
4	1250-1450	6	6.00%
5	>1450	1	1.00%
Total		100	100%

In the present study, NCCT-HU of majority of the stone was between 1050-1250 HU (40%).The CT attenuation of 850-1050 HU was reported in 34% patients. 15% patients had CT attenuation value of 650-850 HU. 6% patients had 1250-1450 HU, 4% patients had less than 650 HU and one patient had CT attenuation more than 1450 HU.

Table 2: Relationship of Chemical Composition with NCCT- HU.

Chemical Composition		HU		
	Frequency	Mean±SD	Minimum	Maximum
CaOMH				
<60%	19	894.74±177.1	650	1250
60-80%	51	1091.74±162.2	650	1300
>80%	30	1063.83±180.6	750	1450
CaODH				
<20%	64	1005.1±193.1	650	1450
20-30%	32	1011.8±156.9	650	1300
>30%	4	1050±129.1	900	1200
Matrix				
<5%	73	1032.5±171.2	650	1450
5-10%	8	1053.1±170.3	850	1300
>10%	19	900.5±179.1	650	1250
Phosphate	7	842.85±136.7	650	1050
UA	7	907.14±212.9	650	1250
CA	2	1000±353.5	750	1250

In the study, chemical composition of calculi of all the patients were done after doing NCCT-HU and respective interventions & surgery for the stones at different locations. All the calculi on chemical analysis showed mixed chemical composition. Calcium oxalate monohydrate was the major composition in the study. Maximum calculi showed CaOMH (calcium oxalate monohydrate) of 60-80% having mean CT attenuation of 1091.74±162.2 HU. Calculi comprising of CaODH (calcium oxalate dihydrate) (<20%) were seen in 64 patients with mean CT attenuation of 1005.1±193.1 HU. 7 patients each had mixed phosphate stone and uric acid (UA) stone with mean CT attenuation of 842.85±136.7 HU and 907.14±212.9 HU respectively. Only 2 patients had carbonate apatite (CA) stone with mean CT attenuation of 1000±353.5 HU. Majority of matrix composition in the calculi was less than 5% which was seen in 73 patients with mean CT attenuation value of 1032±171.2 HU.

Table 3 : Co-relations of NCCT-HU with chemical composition of urolithiasis

NCCT-HU		CaOMH	CaODH	MATRIX	UA	CA	Phosphate
	Pearson Correlation	0.305	0.157	- 0.305	-0.152	0.010	0.07
	Sig. (2-tailed)	0.002	0.119	0.002	0.132	0.924	0.009

CaOMH, Matrix and phosphate stone were significant co-related with the NCCT-HU with p value of 0.002, 0.002 and 0.009 respectively as shown in figure 12, 13 &14.

Discussion

Many studies have attempted to analyze stone composition with HU measurements. According to Motley et al. stones were classified as uric acid, calcium oxalate or calcium phosphate based on CT attenuation[4]. The following table shows correlation of chemical composition with CT attenuation in different studies.

Chemical composition	Mean HU			
	Gupta et al[5](2005)	Mostafavi et al[6] (1998)	Hillman et al[7] (1984)	Kuwahara et al[8] (1984)
Calcium oxalate monohydrate	1008	1645	1077	1690
Calcium oxalate Dihydrate	748	1417	865	1690
Carbonate apatite	444	-	-	1400
Uric acid	391	409	426	480
Struvite	662	666	725	1285
Calcium mono and dehydrate	1036	-	-	1555

Most of the calculi in the clinical setup are mixed type and only the retrieved component of the calculus is analyzed for chemical composition which may not represent all the constituents of the calculus. Hence the CT attenuation depends upon the percentage of various constituents in the calculi as depicted in the following table.

Present study			Nakasato et al[9] (2015)	
Composition % (n)		Mean HU ± SD	Chemical composition	Mean HU ± SD
CaOMH	>80% (30)	1063.83±180.6	100-80%	772±224
	60-80% (51)	1091.74±162.2	<80-60%	807±221
	<60% (19)	894.74±177.1	<60-50%	736±173
CaODH	>30% (4)	1050.0±129.1	100-80%	694±224
	20-30% (32)	1011.8±156.9	<80-60%	672±177
	<20% (64)	1005.1±193.1	<60-50%	761±236
Matrix	>10% (19)	900.5±179.1	-	-
	5-10% (8)	1053.1±170.3	-	-
	<5% (73)	1032.5±171.2	-	-
Carbonate apatite	(2)	1000±353.5	-	-
Uric Acid	(7)	907.14±212.9	-	412±40
Calcium Phosphate	(7)	842.85±136.7	-	758±231

In the present study, all calculi showed mixed chemical composition. None of the retrieved calculi showed were found to be pure. Maximum calculi (n=51) showed calcium oxalate monohydrate (CaOMH) of 60-80% as one of the constituents having mean CT attenuation of 1091.74±162.2 HU. Calculi comprising of calcium oxalate dihydrate (CaODH) (<20%) as one of the constituents was found in 64 patients with mean CT attenuation of 1005.1±193.1 HU. Matrix was found as a composition in all samples retrieved. Majority (n=73) of the samples had less than (<) 5% composition with mean CT attenuation value of 1032.5±171.2 HU. 7 patients each had mixed type of calcium phosphate and uric acid stone with mean CT attenuation of 842.85±136.7 HU and 907.14±212.9 HU respectively. In 2 patients carbonate apatite stone composition was seen which had mean CT attenuation value of 1000±353.5 HU.

CaOMH, Matrix and calcium phosphate stone were significantly co-related with the NCCT-HU with p value 0.002, 0.002 and 0.009 respectively.

Conclusion

In the present study, chemical composition of the urolithiasis by FTIR method showed mixed type of calculus. None of the stones were pure. Maximum stones had mixed calcium oxalate crystals. Phosphate, uric acid and carbonate apatite crystals were other type of composition which were present in the study samples. They were also found in combination with matrix, thus rendering them impure.

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