JOURNAL OF CLINICAL AND DIAGNOSTIC RESEARCH

How to cite this article:
NATEKAR PRASHANT E, DIAS MEDORA C,ULMAN SHRUTIN,DURGAPRASAD Y.VISUALISATION OF RENAL CALCULI USING C – ARM FLUOROSCOPY.Journal of Clinical and Diagnostic Research [serial online] 2009 December [cited: 2009 December 7]; 3:1968-1971.

Available from
http://www.jcdr.net/back_issues.asp?issn=0973-709x&year=2009&month=December &volume=3&issue=6&page=1968-1971 &id=519

EXPERIMENTAL RESEARCH

Visualisation Of Renal Calculi Using C – Arm Fluoroscopy

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ABSTRACT

The present study was carried out on cadavers to ascertain the resolving power of C - arm fluoroscopy (mobile) unit. Renal calculi of different sizes were collected from the patients and these calculi were then implanted in the urinary tract of cadavers, at the common sites of impaction. It was seen that calculi as small as 3mm could be identified. However classification of the calculi i.e., prediction of stone composition based on image characteristics was not possible.

Key Words: renal calculi; ureteric calculi, C-arm fluoroscopy; calcium stones; uric acid stones

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Introduction

Renal calculus is the commonest condition resolved on X- ray, hence the radiogram forms the most important piece of evidence in the diagnosis of the renal calculi. A calculus is a progressive conglomeration of crystalloid bodies bound together by a cement substance. The former are precipitated out of the urine; the latter, in which they reach saturation by absorption, is provided by the plasma in the form of an irreversible colloid (such as fibrin) [1]. It is well known that the problem of renal or ureteric calculi is very large worldwide. Renal colic or ureteric colic patients need quick diagnosis and immediate treatment. It may be a self limiting condition due to spontaneous passage of small calculi of less than 5mm size and complete recovery up to 93% of patients with acute urinary tract calculus obstruction or persisting pain or high grade obstruction may require hospitalization and urological intervention [2],[3].

Plain abdominal x ray for kidney, ureter and urinary bladder (KUB) used alone is of limited diagnostic value with a sensitivity of 53-62% and specificity of 67-69% for detection of ureteral calculi [4]. Ultrasound proved to be a non invasive, safe technique, which efficiently detected acute urinary tract obstruction. Ultrasound used alone had some limitations, being an operator dependent technique. Sensitivity of ultrasound increases when used along with X- ray with KUB. Intravenous urography is not likely to be helpful when the results of plain X- ray and ultrasound were negative [5].

It is unusual to have a stone of pure chemical substance. One of the components may predominate but there are always at least traces of others. The radiographic visualization of the calculus depends on its opacity to X - rays. Apart from its size and porosity, it will also depend on its chemical composition and atomic number of elements composing it. A calculus containing calcium, phosphate, magnesium or sodium will cast a shadow in the radiogram. Very rarely, the urinary calculi is composed of a similar salt, however its nucleus consist of ammonia, urates in infants, uric acid in young adults and calcium oxalates in patients above the age of 40. The laminae will be composed of uric acid, ammonia and sodium and magnesium phosphates cysteine and xanthines.

The main aim of this pilot study is to ascertain the resolving power of the C-arm fluoroscopic system with regard to commonly occurring renal stones and also whether the C-arm fluoroscopic system would actually be able to detect or visualize the renal or ureteric calculi based on resolution of size of stone, chemical composition of stone or position of the stone in the urinary tract.

Materials and Methods

This study was carried out in the Department of Anatomy at Goa Medical College, Bambolim Goa. Renal stones were collected from patients who were operated in Goa and were classified into various sizes. The cadavers were dissected from the anterior abdominal wall by a midline incision from the xiphisternum to the pubic symphysis. The rectus sheath was incised and the peritoneum was separated. The intestines and other organs were separated and both the kidneys, ureters and urinary bladder were exposed.

These stones were placed at the following locations in the urinary tract of the cadaver:

- Lower pole of kidney.
- Pelvi – ureteric junction.
- Level of entry of ureter at the pelvic brim.
- Opening of ureter into urinary bladder.

A mobile C – arm Fluoroscopic system was positioned around the cadaver and the intensity of the X – rays were increased from low to high to resolve the stones. The size and location of the stones were visualized on a monitor and findings were noted. These stones were also analysed biochemically so as to ascertain its chemical composition.

Observations and Results.

It was observed that all the stones of 3mm size and above could be resolved under C arm fluoroscopy, however stones of 2mm could not be resolved. It was also observed that 3mm size and above could also be resolved at the four commonest site of stone formation as shown in [Table/Fig 1] when the stones were sent for chemical analysis to detect their chemical composition it was observed that the following substances were present in the stones. They were calcium phosphate, calcium oxalate, calcium carbonate, uric acid stones and creatinine.

(Table/Fig 1) Size and location of the stones visualized under C arm fluoroscopy

Location of stones in cadaver	Size of the stones in millimeters				
	2mm	3mm	4mm	5mm	7mm and more
Lower pole of kidney	---	+	+	+	+
Pelvi-ureteric junction	---	+	+	+	+
Level of entry of ureter at pelvic brim	---	+	+	+	+
Opening of ureter into the urinary bladder	---	+	+	+	+

Discussion

In our present study, the following were the main types of urinary stones.

Calcium oxalates. calcium phosphate, calcium carbonate, uric acid and creatinine. Calcium stones amounting to almost 95% of renal stones occur due to presence of excessive calcium in the urine, either because of defective kidney function which allows a lot of calcium to pass into the urine or excess calcium which may be absorbed from stomach and intestine. These are usually single, have a mulberry outline and cast a densest shadow of all the calculi due to larger amount of calcium. Oxalates, present in staple diets of certain population easily binds with calcium to form calcium oxalate stones. Phosphates mostly calcium phosphates or commonly triple phosphates of calcium, magnesium and ammonia tend to grow quickly and assume a corralliform shape. Uric acid calculus being rare does not cast shadow if it is pure, however when it is mixed with urates, they show opacity in a radiogram and usually do not attain a large size.

20% of the urethral calculi are found in the lumbar ureter and the calculi are usually larger than 5mm. The remainder 80% are found in pelvic ureter of which 70% are located in the intramural portion of the terminal ureter. Approximately 95% of the urethral calculi are visible on diagnostic plain X ray films covering abdominal pelvis and the remaining

5% are non opaque composed generally of cysteine, xanthine or uric acid [6].

Nearly all lie above a line joining the inferior margin of the bases of the ischial spines (a line corresponding to the lower level of the intramural section of the ureter). Intravenous pyelograms may show normal pelvis and calyces with little or no urethral dilatation on the side of the urethral calculus. When the calculus appears larger than the ureter, it shows dilatation above the level of the stone. Infrequently a non opaque stone is visible as a filling defect in an unobstructed or blocked ureter. An important secondary sign of calculus at the lower end of the ureter is a filling defect in the bladder due to edema around the urethral orifice. Nearly all patients having a urethral calculus complain of pain on the same side which begin in the loin and often radiates down the anterior abdomen into the inguinal or pubic region which is excruciating and spasmodic.

In evaluating patients with acute ureteric calculus disease Intravenous Urography has traditionally being the imaging modality of choice. Unenhanced spiral CT is also accurate in showing calculi of kidney and ureter and signs of acute obstruction like peri-renal stranding and hydronephrosis[7],[8],[9]. On comparison of performance of unenhanced Spiral CT to the combination of HASTE (Half-Fourier single shot turbo spin-echo) MR Urography (MRU) and plain abdominal radiography (KUB) in patients suspected of having acute calculus ureteric obstruction, it was observed that based on evaluation of presence of peri renal fluid and presence and level of ureteric obstruction and calculi, 69% patients had acute calculus ureteric obstruction and MRU showed peri- renal fluid in acute ureteric obstruction (77%) with a greater sensitivity than CT showed stranding (45%) while the combination of fluid and ureteric dilatation on MRU had 93% sensitivity (CT 80%), 95% specificity (CT 85%) and 94% accuracy (CT 81%). MRU/KUB showed ureteric calculi in 72% of patients with calculi seen by CT and overall it was observed that MRU/KUB technique having less observer variability (Kappa 0.75), revealed 2.4 abnormalities per acutely obstructed ureter compared with 1.8 abnormalities detected by CT [10].

In our present study we have observed that all stones of 3mm and more could be easily visualized under C arm fluoroscopy irrespective of their location. It was also observed that chemical composition had no additional advantage in locating and detecting the stone as all stones could be visualized irrespective of their chemical composition. An additional advantage of C arm fluoroscopy is that very often 3mm stone goes undetected as an artifact or technical error which can be easily diagnosed under C arm fluoroscopy. This study is useful so as to avoid cystoscopic procedures and also because of the mobile unit the same can be utilized in operation theatres for diagnosing the renal calculi. Identification of a stone in a bifid or double ureter, where the diagnosis depends on the skill of the urologist in finding and catheterizing both ureteral orifices. This study also helps in avoiding the differential diagnosis of renal and ureteric calculus. Although digital radiography, intravenous pylography, ultrasonography and CT scan detects the calculi of 3mm size, C arm fluoroscopy also can detect the same especially in operation theatres.

Besides this our study provides findings which are important to surgeons before and during surgical interventions and will also provide immense contribution in treatment of renal and ureteric calculi so as to rationalize the early line of management and treatment both clinically and surgically.

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