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Value of non-contrast CT examination of the urinary tract (stone protocol) in the detection of incidental findings and its impact upon the management

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Abstract *Background:* Urolithiasis is one of the most common urinary tract diseases worldwide, with a wide range of affected age groups. Non-contrast CT examination of the urinary tract is the gold-standard examination for detection and characterization of urinary tract stones, with great impact upon the choice of method of management. Aside from detection of stones, non-contrast CT examination of the abdomen and pelvis also offers a valuable overlook upon the other abdominal organs, pathologies of which may simulate a stone disease, or accompany stone disease and can be detected incidentally, which may shift management plan dramatically.

Aim of work: To demonstrate the use of non-contrast CT examinations (stone protocol) in the detection of abdominal pathologies other than stones, whether or not simulating the clinical picture of urolithiasis, and its impact upon patient management.

Patients and methods: Assessment of the non-contrast examinations of the urinary tract of patients referred for suspected stone urolithiasis recording any incidental finding and follow-up of the impact of these incidental findings upon the management delivered to the patient.

Results: A total of 719 examinations were performed, of which 334 had urinary tract stones only, 211 had incidental finding beside urinary tract stones, 170 had an incidental finding with no urinary tract stones, and four patients had neither stones nor incidental findings. A total number of 381 patients had incidental findings, 198 (47%) of which had an impact upon the management.

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Conclusion: Non-contrast CT examination of the urinary tract (stone protocol) is a valuable tool in the detection of incidental findings which may simulate, or coincide with urolithiasis and it has a significant impact upon the management of the patients.

1. Introduction

Urolithiasis is a common urinary tract pathology that affects a wide range of age group.[1] Multiple treatment options are available for management of urinary tract stones, including medical treatment, Shock Wave lithotripsy, percutaneous nephrolithotomy, as well as open surgery.[2] The major determinants of treatment options are the stone number, site, size, attenuation, as well as the presence or absence of obstruction.[2] Multiple radiological techniques can be used to detect and characterize urinary tract stones, including plain X-ray, intravenous urography, ultrasonography, and computed tomography.[3]

Pain and hematuria are the most common presentations of urinary tract stones. Site and character of pain as well as the amount of hematuria, being gross or microscopic, depend upon the site and shape of the stone among other factors.[4,5] However, pain and hematuria are also common presentation of other urinary tract diseases, and of diseases other than the urinary tract. Gynecological disorders may present with pelvic pain, dysuria and even hematuria,[6] and colonic diseases may give abdominal pain, confusable with renal colic.[7,8] Appendicitis is a common differential diagnosis of an acute abdominal pain, together with right ureteric stone.[8]

Ever since its introduction, computed tomography examination of the urinary system with no contrast, known as CT stone protocol, has become the gold-standard examination for detection and characterization of urinary tract stones, with a sensitivity and specificity approaching 100%, which lead to a breakthrough in the management.[9–12]

Another advantage in CT stone protocol is that it gives an overview of the other abdominal organs and of the peritoneal cavity with possible detection of other incidental pathological processes that may gain a priority in its management over the urinary tract stones, with early detection and hence early management, resulting in better prognosis. CT stone protocol also enables detection of other pathologies that mimic urinary tract

Table 1 Distribution of stones.

Distribution of stones	
Right renal stones	97
Left renal stones	124
Right ureteric stones	83
Left ureteric stones	102
Bladder stones	14
Bilateral renal stones	104
Bilateral ureteric stones	21
Total	545

Table 2 Distribution of all cases.

Distribution of all cases	
Cases with stones only	334
Cases with stones and incidental finding	211
Cases of incidental finding with no stones	170
Cases with no stones or incidental finding	4
Total cases	719

Table 3 Distribution of incidental findings between Group 1 and Group 2.

Group 1 incidental findings related to the urinary tract		Group 2 incidental findings related to organs other than the urinary tract	
Finding	Number	Finding	Number
Renal Cysts	161	Liver Cirrhosis	48
Renal Infections	29	Fatty Liver	34
Renal Tumors	24	Colonic Diverticulosis	24
Adrenal Adenoma	19	Gall Stones	24
Adrenal Myelolipoma	3	Bone Deposits	7
Adrenal Carcinoma	1	Extra-uterine contraceptive device	3
Double Moeity	17	Appendicitis	3
Renal Ectopia	10	Hydrosalpinx	1
Ureteric Stricture	7	Meckel's Diverticulitis	1
Horse-Shoe Kidney	5	Situs Inversus	1
Medullary Sponge Kidneys	2	Uterine Prolapse	1
Autosomal Dominant Polycystic Kidney Disease with a bladder diverticulum	1		
Putty Left Kidney	1		
Renal Granuloma	1		
Urinary tract Tumors	2		

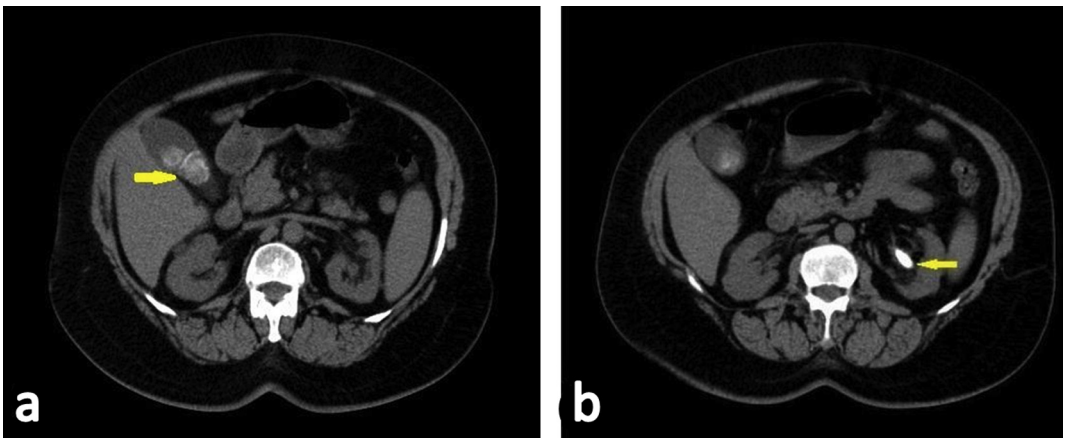

Figure 1 Fifty-two year old female patient with bilateral flank pain. CT stone protocol in axial plane at the level of gall bladder (a) showing gall bladder stones (arrow). (b) Axial scan at the left of left renal hilum shows a left renal pelvic stone (arrow).

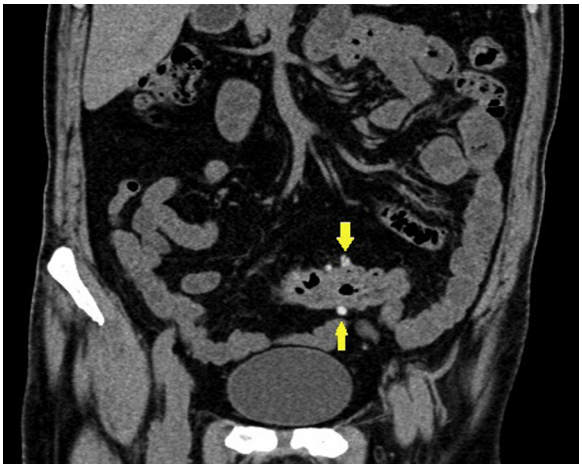

Figure 2 Fifty-six year old male patient with left flank pain. CT stone protocol shows small diverticula in the sigmoid colon (arrows). No stones were found.

stone in its symptoms and signs, and so redirecting the management plan to its correct path.[13–15]

2. Methods and materials

This is a prospective study that included a total of 719 patients who had CT stone protocol examinations performed by a 16-detector CT Siemens Somatom Sensation, with no oral or intravenous contrast medium administration, during the period between May 2012 and December 2014, with clinically suspected urinary tract stone disease.

No patient preparation was required, apart from assuring a full urinary bladder.

Patients lied on CT table in supine position, with elevated arms behind the head. Initially a topogram in antero-posterior view was extended from the lower chest down to the upper thighs. Then, scans were obtained from the dome of the liver to below the ischial tuberosities using 1.5 mm slice collimation and images were reconstructed at 1 mm slice thickness and 0.75 intervals. Setting of the exposure factors had been 130 KVp and 200 mAS.

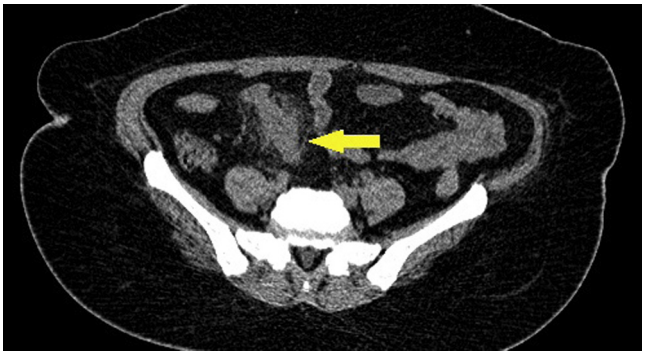

Figure 3 Thirty-four year old female patient with right sided abdominal pain and dysuria. CT stone protocol revealed an oblong tubular structure related to the ileal loops, with stranded adjacent fascial planes, proven at surgery to be an inflamed Meckel's diverticulum.

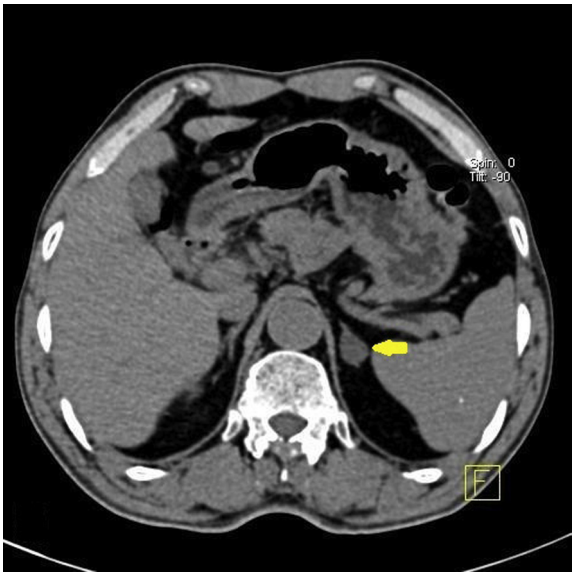

Figure 4 Thirty-four year old male patient with bilateral flank pain. In addition to bilateral renal stones, CT stone protocol shows a left adrenal lipid-rich adenoma (arrow).

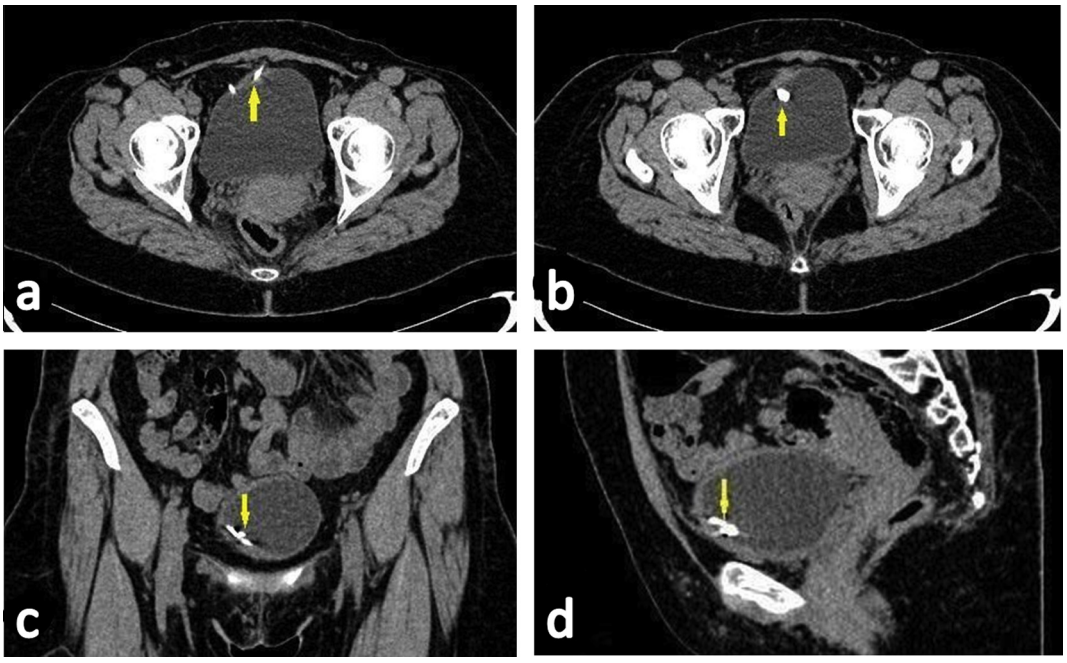

Figure 5 Forty-one year old female patient with dysuria and hematuria. CT stone protocol revealed a contraceptive device that penetrated into the urinary bladder lumen. (a) Axial cut at the urinary bladder showing the two limbs of the device (arrow). (b) Axial cut at a lower level showing the stem of the device (arrow). Coronal (c) and sagittal (d) showing the contraceptive device (arrows).

Exclusion criteria included any patient with a known disease (either urinary or extra-urinary) other than the suspected urinary tract stone.

Follow-up of the cases with incidental findings was done with documentation of the impact of detection of the incidental pathology upon management.

Informed consent was obtained from all individual participants included in the study.

3. Results

A total of 719 CT stone protocol examinations were obtained. 467 of the patients were males (65%) and 252 were females (35%), age ranged from 15 years and 68 years.

334 patients (46%) had urinary tract stones only with no other associated pathologies detected by non-contrast CT, Table 1 and 211 patients (29%) had incidental finding beside urinary tract stones, 170 patients (24%) had an incidental finding with no urinary tract stones, and four patients (1%) had neither stones nor incidental findings seen in non-contrast CT study Table 2.

The most common symptom encountered in the study was flank pain (right in $n = 280$, left in $n = 226$, bilateral in $n = 129$), followed by hematuria ($n = 110$) and finally dysuria ($n = 21$).

A total number of 381 patients (53% of total patients) had incidental findings, and these incidental findings were divided into two groups: group 1 with incidental findings related to the urinary system (66%), and group 2 related to organs other than the urinary system (34%); Table 3.

Considering the patients with extra-urinary incidental findings (group 2), the most of the incidental findings were related to the hepato-biliary system; 106 patients (62%) (Fig. 1), followed by the bowel (Figs. 2 and 3); 28 patients (16%), adrenal masses; 23 patients (14%) (Fig. 4), bone deposits; seven patients (4%), followed by gynecological disorders; five patients (Fig. 5) and one patient with situs inversus.

On the other hand, renal cysts were the urinary tract related incidental finding most commonly encountered (only one cyst of about 6 cm diameter caused renal pain and hence required

Figure 6 Thirty-four year old female patient with left flank pain. CT stone protocol in sagittal oblique plane through the left kidney shows a parapelvic cyst causing mild dilatation of the upper calyx with no stones. Cyst aspiration and sclerotherapy relieved the pain.

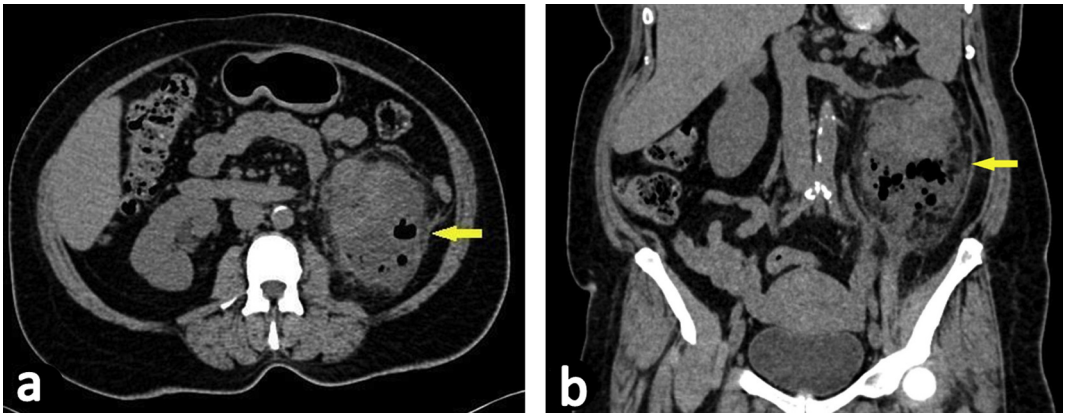

Figure 7 Fifty-three year old diabetic female patient with left flank pain. CT stone protocol in axial (a) and coronal (b) planes through the kidneys shows left renal abscess (arrows). No stones were found.

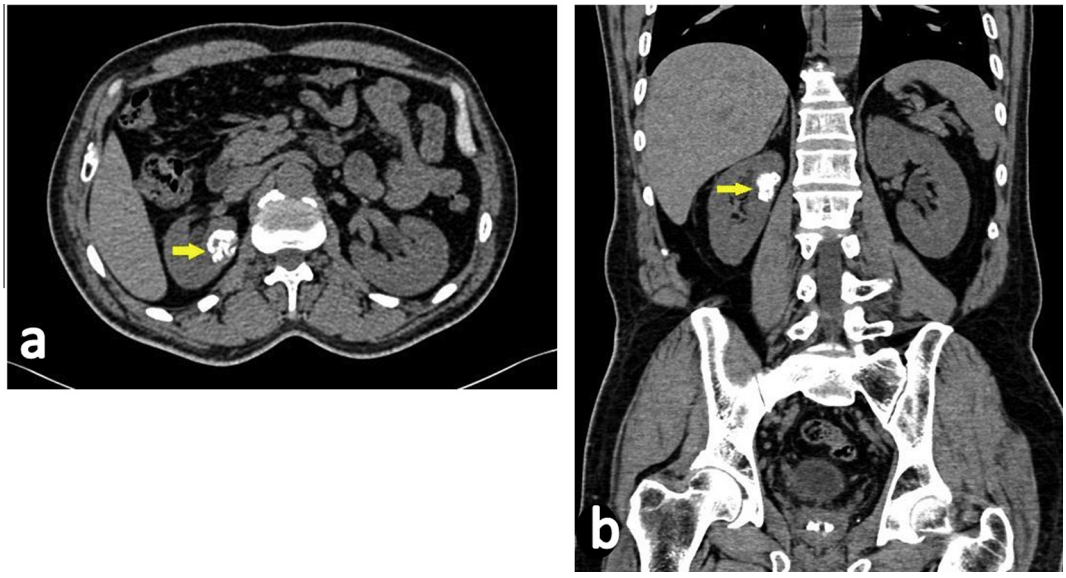

Figure 8 Sixty-one year old female patient with right flank pain. CT stone protocol through the right kidney in axial (a) and coronal (b) planes shows dense parenchymal calcifications (arrows). No underlying masses or stones were found and stationary size was found on follow-up, and so considered as granuloma.

intervention) (Fig. 6); 161 patients (62%), followed by renal infections; 29 patients (11%) (Figs. 7–9), urinary tract tumors; 24 patients (9%) (Figs. 10 and 11), and double-moiety; 17 patients (7%).

From the total 381 patients with incidental findings, the discovered incidental findings had an impact on the management in 198 patients (47%), either in the form of diet adjustment, medical treatment or even surgical intervention (open surgery or endoscopy). Two patients had medullary sponge kidneys (Fig. 12).

Table 4 shows the patients with incidental findings, and the modification of management they received

4. Discussion

Flank pain and hematuria are common presentations of urinary tract calculi. However, a number of other pathologies in different abdominal organs and in the urinary tract itself can give a similar presentation. We aimed in our study to assess the utility of non-contract CT examination of the urinary tract (stone protocol) in the detection of the pathologies other than urinary tract stones which mimic their symptoms and signs, and comparing our results with other similar studies.

Ather et al.[13] studied 4000 patients suspected to have urinary tract stone, and found an alternate diagnosis in 398 patients (9.9%), which is different than our finding of 24% stone-free patients, and it should be noted that in this study – in addition to the different sample size - the search was for a cause for the complaint other than stone; however, in our study the search was for concomitant as well as for alternate diagnosis. Ather et al. also noted a wide spectrum of significant alternate diagnoses including urogenital (76.6%) and non-urogenital (23.4%) conditions that could be reliably established or

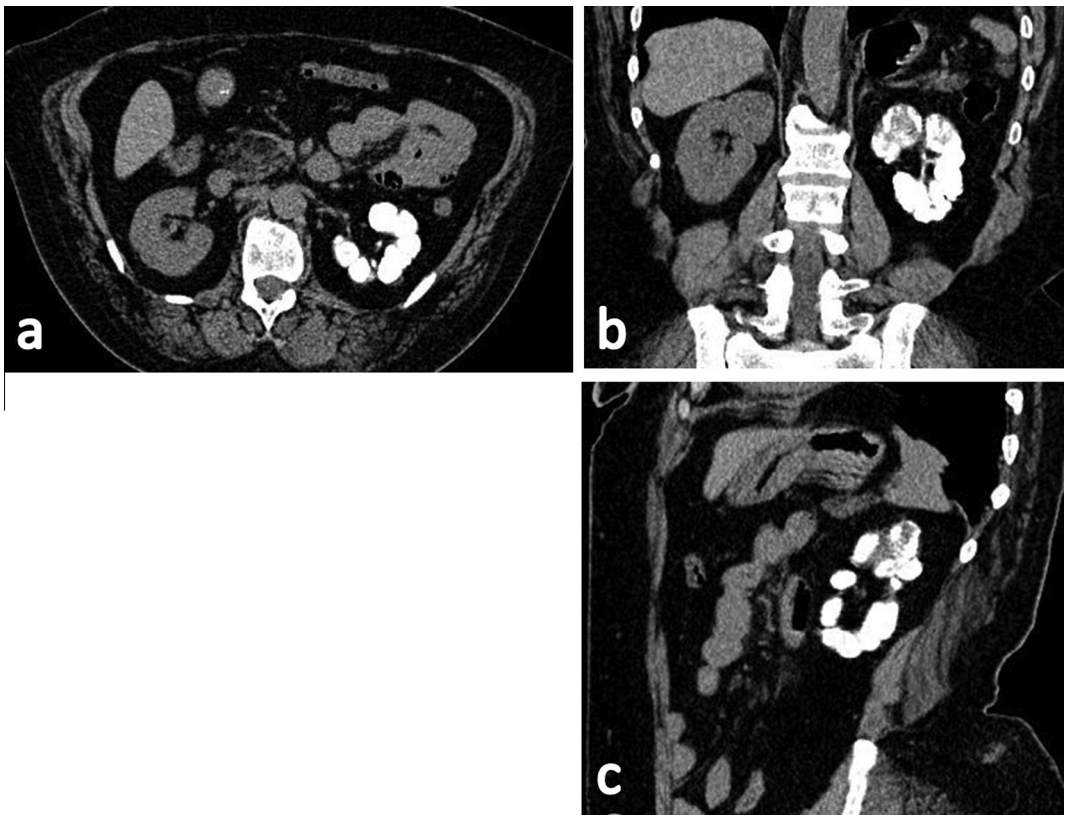

Figure 9 Sixty-eight year old female patient with left flank pain. CT stone protocol through the left kidney in (a) axial, (b) coronal, and (c) sagittal planes revealed a small calcified left kidney, consistent with putty kidney.

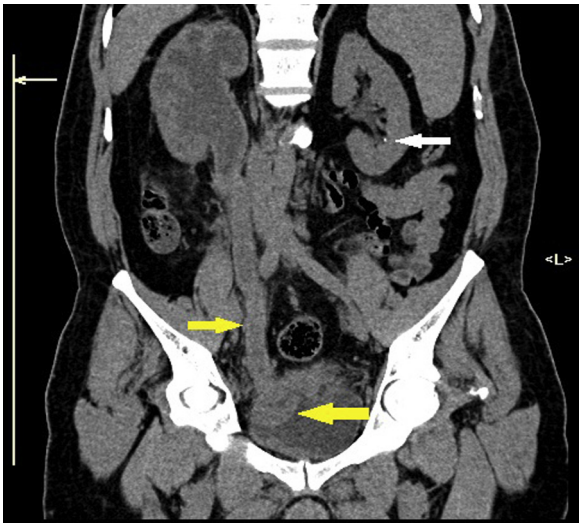

Figure 10 Sixty-one year old male patient with right flank pain and hematuria. CT stone protocol shows urinary bladder mass at the right vesico-ureteric junction (large yellow arrow) with obstruction of the right ureter, which is filled by mass tissues (small yellow arrow). Small lower calyceal stone was found in the left kidney (white arrow).

suggested on spiral CTs performed for suspected renal colic cases. However, Ather et al. included ovarian lesions in the genitor-urinary group.[13]

In a study conducted by Katz et al.,[14] 1000 stone protocol examinations were reviewed, ureteric stones were found on 557 examinations, findings consistent with a recently passed stone were found on 67 examinations, and 275 CT examinations were free. An alternative or additional diagnosis was found or suggested on 101 examinations (10%), including 26 patients having both urinary tract stone and an incidental pathology. Again, different sample size than that in our study may cause the different percentage of patients with incidental findings. In Katz et al. study, there were 62 incidental findings related to genitourinary system and 39 findings not related to the genitourinary tract. Katz et al. included pathologies related to the female genital system to the urinary tract group, which was separate in our study.

Studying incidental diseases on 233 unenhanced helical computed tomography examinations performed for ureteric colic, Ahmad et al.[16] found stones-only in 148 examinations (64%), findings of recent passage of calculi in 10 examinations (4%) and no calculus in 75 examinations (32%). Overall the incidental findings (additional or alternative diagnosis) were found in 28 (12%) CT scans. They grouped the different incidental diagnoses according to the pathology into inflammatory conditions ($n = 12$), tumors and masses ($n = 12$), and other urological diseases ($n = 4$). However, by analyzing the different incidental pathologies, those related to the urinary tract were 9 (32%), while those not related to the urinary tract were 19 (68%), and the most common extra-urinary pathologies were in adnexal masses and cysts ($n = 6$), followed by gall bladder diseases ($n = 4$) and bowel diseases ($n = 4$).

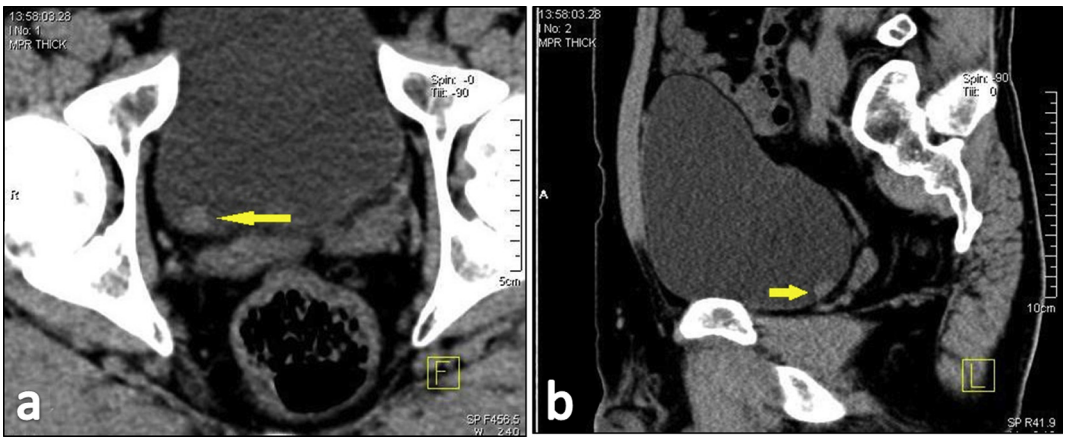

Figure 11 Forty-three year old male patient with left flank pain. CT stone protocol though the urinary bladder in axial (a) and sagittal (b) planes shows small mass lesion in right postero-lateral wall (arrows), turned out by cystoscopy to be a small urothelial tumor.

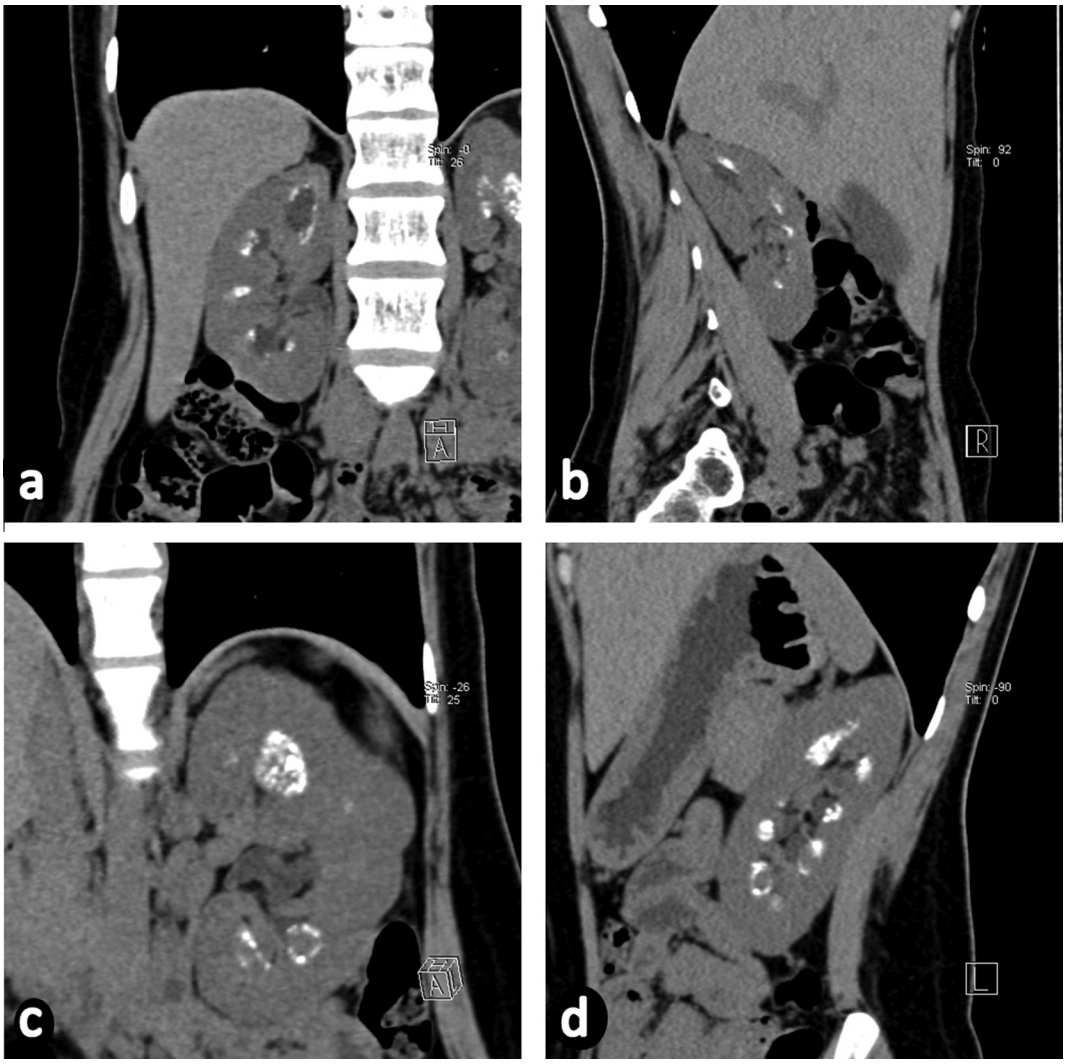

Figure 12 Fifteen year old female patient with bilateral flank pain. CT stone protocol through right kidney in oblique coronal (a) and oblique sagittal (b) and through the left kidney in oblique coronal (c) and oblique sagittal (d) planes, shows bilateral renal medullary calcifications with no stones, diagnosed as medullary cystic kidneys.

Table 4 The patients with incidental findings, and the modification of management they received.

Incidental finding	Total number of patients	Number of patients with impact on management	Change in management
Adrenocortical Carcinoma	1	1	Surgical Adrenalectomy
APKD and a urinary bladder diverticulum	1	1	Open Stone Extraction
Appendicitis	3	3	Appendicectomy
Bone Deposits	7	7	Further search For Primary
Colonic Diverticulosis	24	19	Medical Treatment
Fatty Liver	23	23	Diet modification and Medical Treatment
Fatty Liver With Gall Stones	11	11	Cholecystectomy With diet And Medical Treatment
Gall Stones	13	13	Cholecystectomy
Hydrosalpinx	2	2	Laparoscopy
Perforating contraceptive device	3	3	Endoscopic Extraction
Liver Cirrhosis	48	48	Medical Treatment
Medullary cystic Kidneys	2	2	Medical Treatment
Meckel's Diverticulitis	1	1	Surgery
Renal Cysts	161	1	Cyst Aspiration
Renal Infections	29	29	Surgical And Medical Treatment
Renal Tumors	24	24	Nephrectomies
Stricture	7	7	Dilatation
Urinary tract Tumor	2	2	Cystoscopy
Uterine Prolapse	1	1	Surgery
Total	420	198	

In a study conducted by Hoppe et al.,[17] 1500 patients underwent unenhanced CT due to acute flank pain. 1035 (69%) had urinary tract calculi. Stones alone were found in 331 of these patients (32%) and additional pathological conditions were noted in 704 (68%). Of all patients 1064 (71%) had other or additional CT findings. Of all patients 207 (14%) had non-stone related CT findings requiring immediate or deferred treatment, 464 (31%) had pathological conditions of little clinical importance and 393 (26%) had pathological conditions of no clinical relevance. CT was normal in 105 of all patients (7%).

The different sample sizes in our study and in the mentioned studies contribute to the different percentages of patients with stone-only, stone with incidental findings and patients with alternate diseases. Also the fact that different studies (including our study), different categorization of the individual incidental/alternate findings also contributed to the apparently different results.

Still all studies have agreed that the stone protocol examination adds to the detection of pathologies other than urinary tract stones, which may mimic their presentations, or be incidentally found with urolithiasis.

5. Conclusion

Non-enhanced CT examination of the urinary tract offers the highest sensitivity and specificity in the detection and characterization of urinary tract stones, and is also valuable in the detection of both incidental and alternate pathologies that may be incidentally found, with great impact on patient diagnosis and management.

Conflict of interest

The authors declared that there is no conflict of interest.

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