

Review Article

Contrast versus non-contrast CT in urinary tract calculi

Sofyan Faidah^{1*}, Alyaa Banjar², Jaber Zarbah³, Sarah Alfaer⁴, Mohammed Alshulayyil⁵, Sultan Alsalam⁶, Maher Alsharif⁷, Bassam Bugis⁸, Ahmad Alshangiti⁵, Ziad Alhomidan⁹

¹College of Medicine, Ibn Sina National College, ²Department of Medicine, Jeddah Eye Hospital, Jeddah, Saudi Arabia

College of Medicine, ³Najran University, Najran, ⁴Tabuk University, Tabuk, ⁵King Saud bin Abdulaziz University for Health Sciences (ksau-hs), Riyadh, ⁷King Abdulaziz University, Jeddah, ⁸Umm Al-Qura University, Mecca, ⁹Sulaiman Al Rajhi Colleges, Al Bukairiyah, Saudi Arabia

⁶Department of Medicine, Maternity and Children Hospital, Jeddah, Saudi Arabia

Received: 12 January 2018

Accepted: 29 January 2018

*Correspondence:

Dr. Sofyan Faidah,

E-mail: sofyan.faidah@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

The incidence and prevalence of urinary tract calculi has increased significantly during the past decade. Accurate fast diagnostic modalities were developed to cope with such an increased trend. To date, non-contrast CT scan remains the diagnostic modality of choice for evaluation of patients with urinary tract calculi. However, contrast CT scans are gaining more interest. In this review, both diagnostic modalities were reviewed with the advantages and disadvantages of each. Non-contrast CT scan is a rapid, accurate, less hazardous, less expensive imaging modality that has a high sensitivity in detection of urinary calculi as small as 3 mm. However, it cannot evaluate other probable causes of flank pain. Thus, contrast CT scans can be used in situations where clinical presentation is suspicious and the possibility of other differential diagnoses is considered. Contrast CT scans do not decrease the sensitivity of detecting urinary calculi, and they do have a higher sensitivity in detecting small grades of obstruction as well as evaluating other possible causes of flank pain such as neoplasms, infectious, or inflammatory aetiologies.

Keywords: Urinary tract calculi, CT, Contrast, Non-contrast

INTRODUCTION

During the past few decades, the incidence and prevalence of urinary tract calculi increased notably.¹ Reports from the National Health and Nutrition Examination survey indicated that, in the United States, there was a considerable increase in prevalence of urinary tract calculi from 7.1% in 1994 to 10.6% in 2012 among males, and from 4.1% in 1994 to 6.3% in 2012 among females.² Similarly, other researches denoted that the incidence and prevalence of urinary tract calculi had increased in different countries such as Germany, Spain, Iran, Japan, and Italy.³ Urinary tract calculi are more prevalent among men than women, however, the recent increase in incidence of urinary tract calculi depicted that

the significant rise in disease incidence among females had narrowed the gender difference from 3.4 to 1.4.⁴ The peak age of incidence was reported to range from 40 to 49 years among the United states and Iran among both genders, whereas Japanese females had a higher peak incidence age ranging from 50 to 59 years.³ The incidence and prevalence of urinary tract calculi had also increased among paediatric population.⁵

Many theories have been proposed to explain such recent increase in incidence of urinary tract calculi among different ages and sexes worldwide. However, the exact aetiology remains elusive. Urolithiasis occurs due to a combination of both genetic predisposition and environmental factors.³ The most common environmental

factors accused of being risky for the development of urinary tract calculi are dietary factors and climate changes.³ Recent increase in consumption of fast food, starchy food, oxalates, sodium, and animal proteins, along with reduction of fluid and calcium intake contributed notably to increased risk of calculi formation.^{3,6,7} Additionally, global warming was reported to be a significant contributor. Studies depicted a proportionate relationship between increased climate temperature and incidence of urinary calculi formation.⁸ Another significant and important contributor of increased incidence as well as prevalence of urinary tract calculi is the enhancement of diagnostic tools. The past few decades have witnessed a notable improvement in diagnostic imaging and techniques that probably resulted in increased incidence and prevalence of the disease.

DIAGNOSIS OF URINARY TRACT CALCULI

Diagnosis of urinary tract calculi depends mainly of the clinical presentation. However, confirmatory investigations are often required. Patients with urinary tract calculi classically present with acute severe flank pain that radiates inferiorly and anteriorly to the groin. The location and radiation of pain depends on the site of urinary calculi. Intense nausea, with or without vomiting, accompany pain in at least 50% of the patients. Haematuria and recurrent urinary tract infection are not uncommon. Some patients may experience symptoms of irritative voiding such as dysuria and frequency. Patients with small non-obstructing calculi may be asymptomatic.⁹

Imaging techniques are used for confirmation of the presence of urinary calculi, for determining the size and burden of the calculi, for diagnosing complications, and for following up the passage of calculi.¹⁰ Many imaging techniques are used for achieving these purposes. In the past, plain abdominal and/or pelvic X-ray radiographs were used for diagnosis. However, their use declined significantly due to the low sensitivity and specificity, missing translucent stones, and the development of new advanced diagnostic modalities.¹¹ Intravenous urography (IVU) was also used to evaluate the degree of obstruction. However, its ability to confirm the nature of the obstructing agent was nil.¹² Abdominal and pelvic ultrasonography (US) are often used in young or pregnant ladies where exposure to radiation is dangerous.¹³ Nowadays, computed tomography is the gold standard for diagnosis and monitoring of patients with urinary tract calculi.¹⁰

NON-CONTRAST CT

Non-contrast CT is a safe and rapid imaging technique that can be used for diagnosis of suspected renal stones. During the last few decades, non-contrast CT scan became the diagnostic technique of choice in evaluating

patients with urinary calculi.^{14,15} It has a sensitivity of 92-95% in detecting urinary tract calculi.^{14,16}

Advantages of non-contrast CT scan

Along with radiopaque stones, CT scan can detect radiolucent calculi (e.g. uric acid calculi) which cannot be visualized by conventional radiography. Furthermore, CT scan can localize the site of calculi through imaging the entire kidney, ureter, and bladder.^{10,15} Bilateral calcified renal stones are visualized in Figure 1 in a non-contrast CT scan. Thin cuts through the abdomen and pelvis can be obtained which allows CT scan to be sensitive to visualize very small calculi down to 3 millimetres.¹⁷ Because of the availability of axial, sagittal, and coronal sections, as well as the possibility to create multiplanar reconstruction provide sufficient data about the location, size, and burden of urinary calculi.^{15,18} Additionally, non-contrast CT scan is a rapid accurate technique that can be performed in a few minutes (average 5 minutes) in comparison to an average of 80 minutes required to perform an intravenous urography (IVP). It does not necessitate previous prior renal function or blood tests, and it does not carry the risk of contrast reaction. The radiation dose is also lesser than that required for intravenous urography (IVP), and the nature of the calculus can be determined (e.g. uric acid, struvite, and calcium oxalate) through measuring their density (Hounsfield unit (HU)).^{19,20} During IVP, on the other hand, all calculi appear as filling defect with no possible nature differentiation. CT scans provide an added value that it can image adjacent structures and help in detecting alternative pathology that can be the cause of pain of flank pain. CT scan has a significant value in diagnosis of urinary tract calculi in obese patients who will not be diagnosed by ultrasonography.²¹

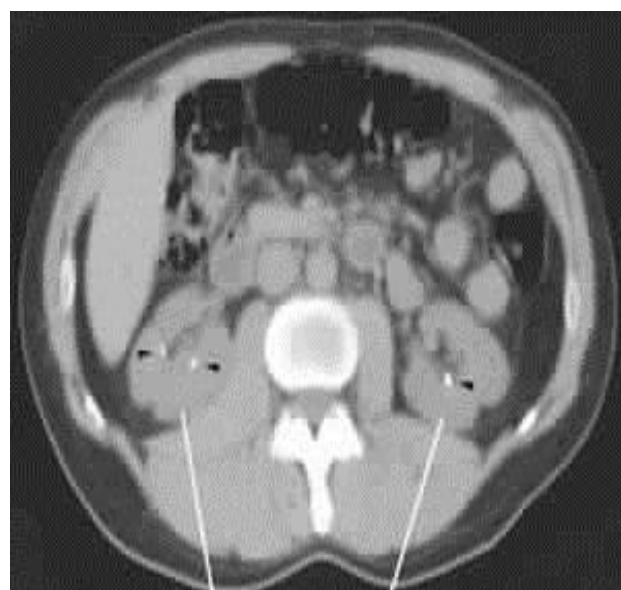


Figure 1: Non-contrast CT scan of the abdomen showing bilateral small calcified renal stones.²²

Disadvantage of non-contrast CT

In spite of being the gold standard for diagnosis of urinary tract calculi, CT scans still have several disadvantages. The main disadvantage is the inability to detect small stones (measuring less than 3 mm) and inability to detect certain types of stones (such as crixivan stones and pure matrix stones formed of mucoproteins and fibrin). The second disadvantage is that CT scans does not provide adequate data about the degree of obstruction of the urinary tract. It has also a limited value in diagnosis of the cause of haematuria. In cases with a paucity of retroperitoneal fat, non-contrast CT scans cannot differentiate small ureteral calculi from phleboliths due to the absence of surrounding rim sign.²³

CONTRAST CT

Contrast CT scan is not commonly utilized for diagnosis of urinary tract calculi, and the non-contrast CT remains the diagnostic tool of choice.^{14,15} Several reasons are probably behind non-utilization of contrast CT in evaluation of patients with suspected urinary tract calculi. On the top of them are the risk of contrast reaction, the longer time consumed, and the belief that the intravenous contrast may decrease the sensitivity for calculi detection. However, no adequate well-designed studies had proved this belief.²⁴ Dym et al, in their review, reported that IV contrast did not seem to decrease the sensitivity of urinary calculi detection. Contrast CT was highly sensitive in detecting calculi as small as 3 mm and even smaller calculi but in lower quality (Figure 2).²⁴ In their study, contrast CT sensitivity was 95% in detecting 3 mm calculi and 99% in detecting calculi 4 mm or more. As regards the risk of contrast reaction, several studies demonstrated a very limited risk of contrast use in most of the patients.^{25,26}



Figure 2: Contrast-enhanced CT image of the right kidney shows a cluster of calyceal calculi without hydronephrosis.¹⁰

Researches who recommend the use of contrast CT explain their recommendation by the fact that the non-contrast CT scans are unremarkable in the vast majority of patients suspected with urinary tract calculi, and an alternative pathology is often the cause of their pain. Contrast CT scans can efficiently diagnose other possible causes of flank pain such as tumours, infections, or inflammatory conditions.^{24,27} Furthermore, contrast CT scans has the same sensitivity of non-contrast CT in detecting signs of urinary tract obstruction (such as perinephric stranding and hydro-nephrosis, and is even more sensitive in detecting very mild obstruction.²⁸

Advantages of using contrast-enhanced CT scans

- Same sensitivity of the intravenous contrast CT scans for detection of urinary tract calculi detection and signs of obstruction (e.g. hydronephrosis and perinephric stranding) as the non-contrast CT scans.
- Higher sensitivity than non-contrast CT in detecting very mild obstruction.
- Detection of alternative pathology as a cause of abdominal or flank pain such as tumours, infections, or inflammatory conditions in cases with normal non-contrast CT scans of the abdomen.

Disadvantages of using contrast-enhanced CT scans

- High risk for contrast reaction
- Longer time consumed than the non-contrast CT scans

CONCLUSION

In conclusion, CT scan remains the diagnostic modality of choice in evaluating patients with suspected urinary calculi. It is rapid, accurate, less hazardous, less expensive and has a high sensitivity in detection of urinary calculi as small as 3 mm. However, it cannot evaluate other probable causes of flank pain. Thus, contrast CT scans can be used in situations where clinical presentation is suspicious and the possibility of other differential diagnoses is considered. Contrast CT scans do not decrease the sensitivity of detecting urinary calculi, and they do have a higher sensitivity in detecting small grades of obstruction as well as evaluating other possible causes of flank pain such as neoplasms, infectious, or inflammatory aetiologies.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

REFERENCES

1. Roudakova K, Monga M. The evolving epidemiology of stone disease. *Indian J Urol*. 2014;30(1):44-8.
2. Thornton SN, Scales Jr CD, Smith AC, Hanley JM, Saigal CS. Urologic diseases in America Project.

- Prevalence of kidney stones in the United States. *Eur Urol*. 2012;62:160-5.
3. Romero V, Akpinar H, Assimos DG. Kidney Stones: A Global Picture of Prevalence, Incidence, and Associated Risk Factors. *Rev Urol*. 2010;12(2-3):86-96.
4. Strobe SA, Wolf JS Jr, Hollenbeck BK. Changes in gender distribution of urinary stone disease. *Urology*. 2010;75(3):543-6.
5. Sas DJ. An update on the changing epidemiology and metabolic risk factors in pediatric kidney stone disease. *CJASN*. 2011;6(8):2062-8.
6. Taylor EN, Stampfer MJ, Curhan GC. Obesity, weight gain, and the risk of kidney stones. *JAMA*. 2005;293(4):455-62.
7. Galal OM. The nutrition transition in Egypt: obesity, undernutrition and the food consumption context. *Public Health Nutrition*. 2002;5(1):141-8.
8. Brikowski TH, Lotan Y, Pearle MS. Climate-related increase in the prevalence of urolithiasis in the United States. *PNAS United States America*. 2008;105(28):9841-6.
9. Chirag Dave KF, Schwartz BF. Nephrolithiasis: Practice Essentials, Background, Anatomy. Available at: <https://emedicine.medscape.com/article/437096-overview>. Accessed on 24 Nov 2017.
10. Kevin Smith MELJ. Urinary Calculi Imaging: Overview, Radiography, Computed Tomography. Available at: <https://emedicine.medscape.com/article/381993-overview#a3>. Accessed on 24 Nov 2017.
11. Dundee P, Bouchier-Hayes D, Haxhimolla H, Dowling R, Costello A. Renal tract calculi: comparison of stone size on plain radiography and noncontrast spiral CT scan. *J Endourol*. 2006;20(12):1005-9.
12. European Association of Urology. EAU Guidelines on Urolithiasis, 2017. Available at: <https://uroweb.org/guideline/urolithiasis/?type=pocket-guidelines>. Accessed on 24 Nov 2017.
13. Pedro RN, Das K, Buchholz N. Urolithiasis in pregnancy. *Int J Surg*. 2016;36:688-92.
14. Coursey CA, Casalino DD, Remer EM, Arellano RS, Bishoff JT, Dighe M, et al. ACR Appropriateness Criteria(R) acute onset flank pain--suspicion of stone disease. *Ultrasound Quarterly*. 2012;28(3):227-33.
15. Brisbane W, Bailey MR, Sorensen MD. An overview of kidney stone imaging techniques. *Nature Rev Urol*. 2016;13(11):654-62.
16. Jindal G, Ramchandani P. Acute flank pain secondary to urolithiasis: radiologic evaluation and alternate diagnoses. *Radiologic Clin North America*. 2007;45(3):395-410.
17. Memarsadeghi M, Heinz-Peer G, Helbich TH, Schaefer-Prokop C, Kramer G, Scharitzer M, et al. Unenhanced multi-detector row CT in patients suspected of having urinary stone disease: effect of section width on diagnosis. *Radiology*. 2005;235(2):530-6.
18. Andrabi Y, Patino M, Das CJ, Eisner B, Sahani DV, Kambadakone A. Advances in CT imaging for urolithiasis. *Indian J Urol*. 2015;31(3):185-93.
19. Fulgham PF, Assimos DG, Pearle MS, Preminger GM. Clinical effectiveness protocols for imaging in the management of ureteral calculous disease: AUA technology assessment. *J Urol*. 2013;189(4):1203-13.
20. Nakada SY, Hoff DG, Attai S, Heisey D, Blankenbaker D, Pozniak M. Determination of stone composition by noncontrast spiral computed tomography in the clinical setting. *Urology*. 2000;55(6):816-9.
21. Vujovic A, Keoghane S. Management of renal stone disease in obese patients. *Nature Clin Practice Urol*. 2007;4(12):671-6.
22. Your Surgery, Urinary Stones. Available at: <http://www.yoursurgery.com/ProcedureDetails.cfm?BR=7&Proc=60>. Accessed on 05 Jan 2018.
23. Dyer RB, Chen MY, Zagoria RJ. Classic signs in uro-radiology. *Radiographics: a review publication of the Radiological Society of North America, Inc*. 2004;24:247-80.
24. Dym RJ, Duncan DR, Spektor M, Cohen HW, Scheinfeld MH. Renal stones on portal venous phase contrast-enhanced CT: does intravenous contrast interfere with detection? *Abdominal Imaging*. 2014;39(3):526-32.
25. McDonald RJ, McDonald JS, Bida JP, Carter RE, Fleming CJ, Misra S, et al. Intravenous contrast material-induced nephropathy: causal or coincident phenomenon? *Radiology*. 2013;267(1):106-18.
26. Newhouse JH, RoyChoudhury A. Quantitating Contrast Medium-induced Nephropathy: Controlling the Controls. *Radiology*. 2013;267(1):4-8.
27. Salama JK, Saba N, Quon H, Garg MK, Lawson J, McDonald MW. American College of Radiology Appropriateness Criteria. *Oral Oncology*. 2011;47(7):554-9.
28. Cheng PM, Moin P, Dunn MD, Boswell WD, Duddalwar VA. What the radiologist needs to know about urolithiasis: part 2--CT findings, reporting, and treatment. *AJR*. 2012;198(6):548-54.

Cite this article as: Faidah S, Banjar A, Zarbah J, Alfaer S, Alshulayyil M, Alsalami S, et al. Contrast versus non-contrast CT in urinary tract calculi. *Int J Community Med Public Health* 2018;5:818-21.