



Radiology Rounds

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Dual Energy CT for Renal Stones

- Multidetector CT (MDCT) scanning using two energy levels, 80kVp and 140kVp MDCT can be used to characterize renal stone composition prior to treatment
- Dual energy MDCT can be performed with sequential scans on a standard MDCT scanner or simultaneous scans on a dual source MDCT scanner
- Dual energy scanning can increase the radiation dose by 10-20% over standard stone protocol MDCT but uses a lower radiation dose than that for other abdominal examinations

Renal colic is a common presentation, with patients complaining of moderate to severe flank pain with or without hematuria. Unenhanced low-dose multidetector CT (MDCT) is recognized as the most accurate examination technique. It shows the precise location and size of renal stones within the kidney, the ureters, and the bladder. If the MDCT examination shows a ureteral stone <5 mm, the stone will likely pass and conservative management with hydration, medical expulsive therapy (i.e. alpha-blockers) and analgesia is recommended.

However, if ureteral stones do not pass after a few weeks, or if their size is >5 mm and patient remains symptomatic, then treatment is selected from a number of options, such as extracorporeal shock wave lithotripsy (ESWL) or ureteroscopic lithotripsy laser probes. Similarly, if non-obstructing renal stones increase in size over time or remain symptomatic, treatment such as ESWL, ureteroscopy, percutaneous nephrolithotomy or laparoscopic stone removal is often performed. Knowledge of stone composition is, therefore, essential to select optimal treatment. For example, uric acid stones can be treated with oral dissolution medication, hydration, and urinary alkalization while calcium stones are usually treated either with surgical extraction or SWL. In addition, some stones such as cystine and calcium oxalate monohydrate are resistant to ESWL.

Although uric acid stones are generally less radio-opaque than other stones, standard MDCT cannot reliably characterize stone composition. Generally, stones that have attenuation values of <400 Hounsfield units (HU) are considered to be composed of uric acid. However, the measurement of HU is dependent on accurate placement and size of the region of interest (ROI). In addition, stones may be of mixed composition and stones of different types can be present in the same patient.

Dual Source CT

Dual source CT scanners were developed primarily for high-speed acquisition for cardiac imaging. However, the two x-ray tubes can be set at different energies (kVp) and dual energy scans can be acquired concurrently. The spectra of X-ray attenuation of different materials depend on their material composition. The attenuation of soft tissues does not vary much within the energy range used in CT, but materials containing substances with high atomic weight, such as calcium, vary considerably. Uric acid and non uric acid stones behave differently with respect to their attenuation values when scanned with CT at different energies. Software is available with dual source CT scanners that takes advantage of these differences and uses a decomposition algorithm to differentiate between uric acid stones, non-uric acid stones, and soft tissue. The resultant images are color coded to show uric acid stones as red (Figure 1) while non-uric acid stones, bone, and other calcified deposits are depicted in blue (Figures 1 & 2). Phantom studies of 40 human renal stones of known composition, 2-7 mm in diameter, have shown that dual energy CT could differentiate between uric acid and non-uric acid stones with 100% accuracy and 100% sensitivity for medium and large phantom sizes and 93% accuracy and 94% sensitivity for the extra large phantom. This suggests that DECT will be highly accurate for normal weight individuals but somewhat less accurate for those who are overweight.

Since this technology has been introduced recently, there is limited data with the use of dual energy CT data for patients with renal stones. However, in a preliminary study in which 20 patients with suspected renal stones were scanned with dual energy CT, uric acid stones were all color coded red by the software and all calcified stones appeared blue, allowing their clear differentiation. However, there was overlap between the mixed stones containing both uric acid

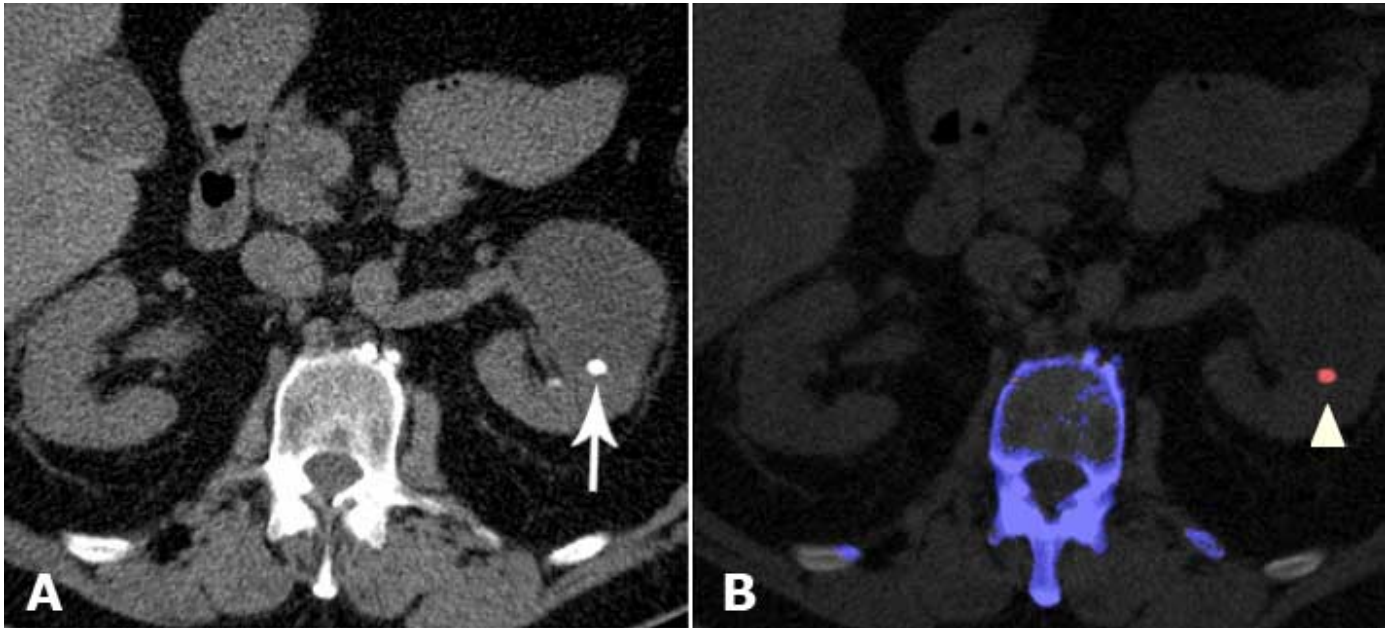


Figure 1. (A) Axial unenhanced abdominal CT scan in a 43 yr-old-man shows a calculus in the left mid pole (arrow). **(B)** Corresponding color-coded dual energy post processed image shows the calculus coded as red (arrowhead) indicating a uric acid stone.

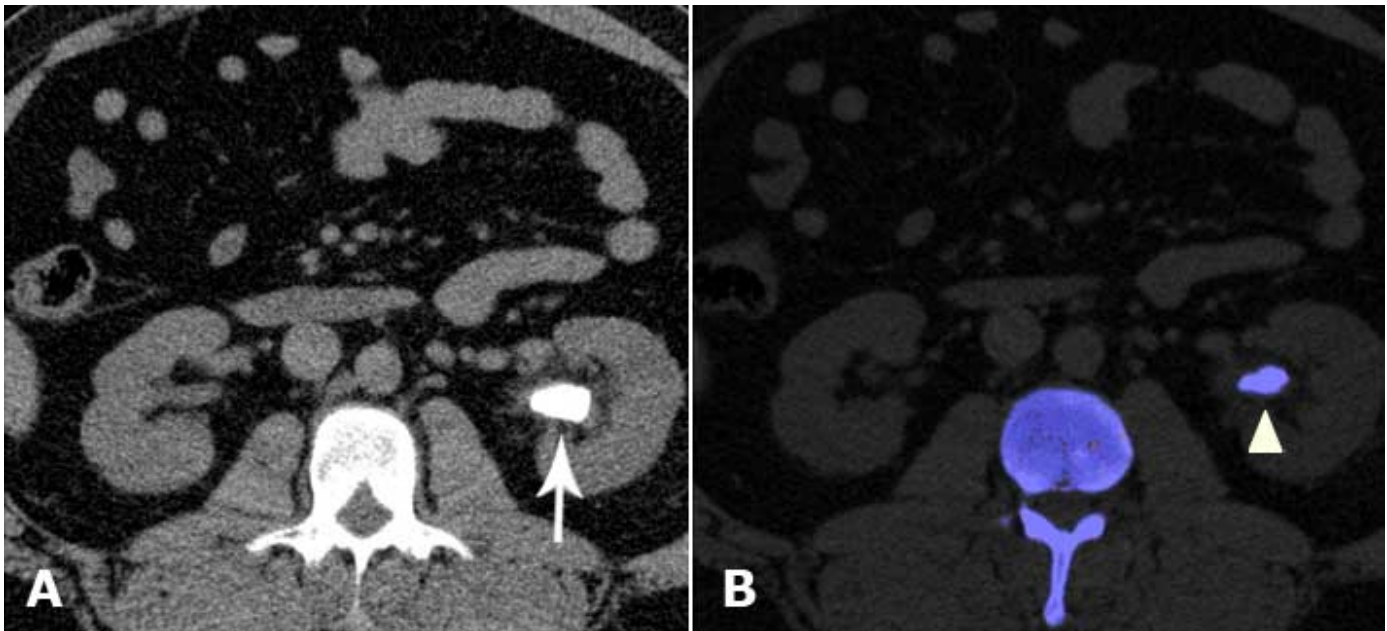


Figure 2. (A) Axial unenhanced abdominal CT scan in a 36 yr-old-man shows a large calculus in the left renal pelvis (arrow). **(B)** Corresponding color-coded dual energy image after post-processing shows the calculus coded as blue (arrowhead) indicating a non-uric acid stone.

and calcium and stones containing struvite or cysteine. Our own experience with ex-vivo experiment and ongoing clinical study has yielded similar results.

Dual Energy CT Renal Stone Protocol

In order to minimize radiation exposure at our institution, the patient is first scanned with a standard low-dose renal stone CT, using a tube potential of 120 kVp and very low tube current. Scanning range is customized to cover the region of interest. A radiologist reads the CT while the patient remains on the scanner table and if a stone is detected, a second dual energy scan (using 80 kVp and 140 kVp) is performed focusing on the region of the stone only. Although the radiation

dose is about 5-10% greater with this method than a standard low dose stone protocol CT, it is substantially lower than most abdominal CT examinations (40-60% lower dose).

Dual source CT scanners with dual energy scanning capability have only recently become available for clinical use and further research is needed before their usefulness in evaluating renal stones will become better understood. At this time, dual energy CT is recommended for patients with a new diagnosis of a renal stone and who require stone characterization prior to treatment. Dual energy CT is not necessary for follow-up studies.

Scheduling

A dual source CT scanner is installed on the Boston campus at MGH mainly for cardiac imaging and is available for renal stone examinations and other potential non-cardiac applications on a space available basis. Dual source CT scans can be scheduled by calling 617-724-1036 between 8 am to 5 pm at or by e-mailing [Cristy Savage](#) or [Avinash Kambadakone, M.D.](#)

Further Information

For further questions, please contact [Dushyant Sahani, M.D.](#), Director of CT Imaging Services, Abdominal Imaging and Intervention, Department of Radiology, Massachusetts General Hospital at 617-726-3937.

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