Imaging of renal stones *in vitro* with UTE MRI

A. Yassin[1], I. Pedrosa[1], M. Kearney[2], E. Genega[3], N. M. Rofsky[1], and R. E. Lenkinski[1]
[1]Radiology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, United States, [2]Urology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, United States, [3]Pathology, Beth Israel Deaconess Medical Center, Harvard Medical School, Boston, MA, United States

Purpose: To characterize the magnetic resonance (MR) imaging properties (i.e. T1 and T2 relaxation times) of a variety of kidney stone specimens using an ultra-short echo time sequence (UTE) and to correlate to their size, composition, and attenuation on computed tomography (CT).

Material and methods: This HIPAA-compliant study was approved by the institutional review board and informed consent was waived. Between April 2009 and September 2009, thirty-six patients with renal stones seen on CT underwent either extraction of one or more kidney stones in the urology clinic or the stones passed spontaneously. Stones from these 36 patients were submitted for MR imaging (GE SIGNA HDX 1.5 T scanner) using two ultra-short echo time (UTE) MR strategies: 1) TR= 1 sec with multiple TE's ranging from 0.1 msec up to 2 msec to calculate the T2 relaxation time of the stones; 2) TE=0.1 msec and multiple TR from 500 msec up to 2.5 secs was also used to calculate their T1 relaxation time. The results were compared to the previous data obtained from experiments measuring the T1 and T2 of pure calcium oxalate and hydroxyapatite crystals suspended in water. The T1 and the T2 were calculated using progressive saturation for T1 and T2 decay for each stone. The stones were then imaged on a micro CT system (InVeon, Siemens Medical Solutions, Knoxville, TN) with tube voltage: 65 KVp, and exposure 1500 ms. Finally, the stones were submitted for chemical analysis and their size and composition was tabulated. Statistical analysis was done using JMP software.

Results: Thirty-six stones were imaged by MRI with an average size of 0.858 cm (range 0.1-3.3 cm). Twenty-one stones were visible by MRI, ranging from 0.15 to 3.3 cm with average size 1.14 cm. These stones had bright signal on UTE imaging relative to a reference tube containing a solution of water and hydroxy apatite (Fig 1). The T1 and T2 of stones visualized on MRI were as follows; the T1 values ranged from 138-3000 msec with a mean value 949 msec while the T2 values ranged from 0.27 to 5.8 msec with a mean value 2.55 msec. The T1 and T2 values for the different stone composition is shown in Fig. 2. Thirty-five out of thirty six stones were identified by micro CT.

Conclusion: The T1- and T2-relaxation time of kidney stones is variable and depends on the stones' composition. Lack of visualization of stones on MRI is likely due short T2s and small size. The lower limits for detection need to be understood when implementing a MR protocol for evaluation of kidney stones. The high signal detected from renal stones shows that this technique is feasible and may be applied on wide scale in patients with renal stones especially in vulnerable groups such as children, women in child bearing age and pregnant females in order to avoid other radiation exposing techniques.

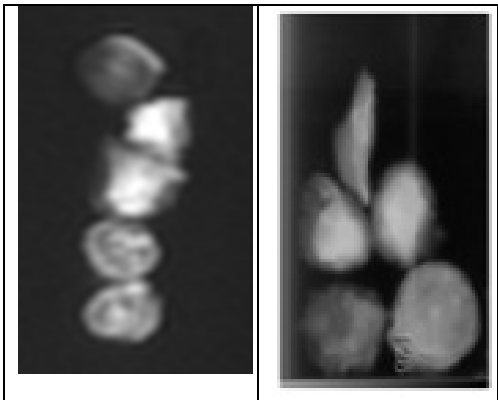

Fig 1. UTE MR image (TR= 1sec, TE =100 μsec) of five kidney stones (left). Micro CT image of the same stones (right).

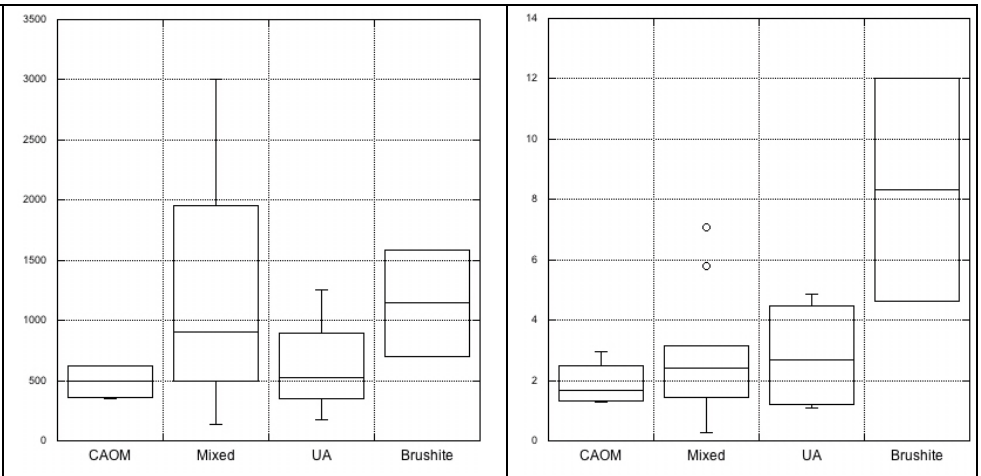

Figure 2. Box and whisker graphs with T1 (left) and T2 (right) values for different stone compositions. CAOM: calcium oxalate monohydrate. UA: uric acid.