Dual energy computed tomography characterization of some urinary stones composition and its dissolution: an in vitro study

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Summary

Introduction:

Urolithiasis is a common urinary system disease. It is an accumulation of various ingredients knowing its chemical composition helps in understanding the pathogenesis, thereby providing guidelines for proper medical management.

With the recent commercial availability of dual energy computed tomography, many investigators have evaluated the ability of this scanning method to identify stone composition before extraction.

Material and Methods:

Dual Energy data set was acquired by single source dual energy helical scan mode with a rapid switching dual energy computed tomography. Dual energy helical scanning alternates between 80 kVp, 460 mA and 135 kVp,80 mA.

Included forty randomly collected urinary stones of unknown compositions. Bovine kidney models were used as a phantom. Cylindrical paraffin wax phantom was used in this study with a diameter of 10 cm. Renal stone samples were inserted in bovine renal pelvis and scanning in dual energy computed tomography. Then repeated this scan after reinserting the bovine kidney containing stones in the wax phantom cavity.

Mean attenuation coefficient of each stone was measured in the dual Energy images once in bovine kidney model and after insertion within wax phantom. Dual energy ratio was calculated by taking the ratio of mean attenuation at both energy levels. The difference in attenuation of the stone was calculated. Also dual energy index was calculated for renal stone samples.

Using X-Ray diffraction to characterize different urinary stone. It can distinguish all different crystal types in a particular mixture. It provides a well organized reliable facility, which can give clinicians reliable results within a few hours.

Prepared in a concentration of 64 g of citric acid anhydrous powder melted in one liter of boiled distilled water. Used for attempt to dissolution of some types of urinary stones.

Results:

The least renal stone (HU) value was 241.5 HU at 80 kV and 218.9 HU at 135 kV using bovine kidney model. While when inserted stones in bovine kidney model within wax phantom were 211.6 HU at 80 kV and 207.4 HU at 135 kV. The highest renal stone HU value was 2198.9 HU at 80 kV and 1572.7 HU at 135 kV using bovine kidney model. And when inserted stones in bovine kidney model within wax phantom were 2246.8 HU at 80 kV and 1686.4 HU at 135 kV.

Dual energy ratio ranged from 1.098 to 1.569 in samples scanned in bovine kidney model and ranged from 1.020 to 1.651 in samples scanned in bovine kidney model within wax phantom. In this study, the calculated dual energy ratio of all renal stone samples was found between 1.098 and 1.569 in samples scanned in bovine kidney model. While dual energy ratio of the renal stone samples was found between 1.020 and 1.651 in bovine kidney model within wax phantom. Dual energy ratio of less than 1.1 was characteristic for uric acid stones and ratios of greater than 1.24 indicates calcified stone.

The dual energy index ranged from 0.008 to 0.128 in samples scanned in bovine kidney model and ranged from 0.001 to 0.149 in samples scanned using bovine kidney model within wax phantom. 38 stone out of 40 (95%) samples scanned using bovine kidney model have a dual energy index greater than 0.034 and 2 stone out of 40 (5%) have dual energy index less than 0.034.

Samples scanned using bovine kidney model within wax phantom were 38 stone out of 40 (95%) having a dual energy index greater than 0.034 and 2 stone out of 40 (5%) having dual energy index less than 0.034. Samples scanned in bovine kidney model found 38/40 stone (95%) having a dual energy index higher than 0.0413 and 2/40 stone (5%) having dual energy index less than 0.0269.

Rescanning the same renal stone samples in bovine kidney model after insertion in wax phantom found 38/40 stone (95%) having dual energy index higher than 0.0413 and 2/40 stone (5%) of dual energy index less than 0.0269. In this study, dual energy index values between 0.0071 and 0.0269 were found to be characteristic for uric acid stones and dual energy index higher than 0.0413 was characteristic for calcium one. Confirmation of renal stone chemical composition can be done using fourier transform infrared spectroscopy, X-Ray diffraction and chemical analysis which show a destructive effect to renal stone samples.

In this study, 4 renal stones sample were analyzed using fourier transform infrared spectroscopy method and results were compared with dual energy computed tomography. We observed calcium containing stones in 2/4 samples (50%) and uric acid containing stones in 2/4 samples (50%) using the fourier transform infrared spectroscopy method. 4 renal stone samples were analyzed using X-Ray diffraction method. constituents of 4 stones have been identified. Renal stones were identified using X-Ray diffraction, and their elemental composition was interrogated through the use of X-Ray diffraction database. We observed calcium containing stones in 2/4 samples (50%) and Uric acid containing stones in 2/4 samples (50%) using the X-Ray diffraction method.

4 renal stone samples were analyzed using chemical methods and current study revealed that 4/4 samples (100%) renal stones were of calcium nature.

In this study, citric acid (64g/liter) shows a great effect in stone dissolution at core temperature rather than room temperature. As the average total dissolution rate of renal stone samples at room temperature level was found between 240 hours and 552 hours. And at core temperature found between 288 hours and 360 hours.

Conclusion:

Despite the use of dual energy computed tomography in diagnosis of urinary system stones concerning their site, volume it also used to determine renal stones composition.

Using wax phantom in dual energy computed tomography scanning that referred to the volume of perinephric fat surrounding the kidney have no effect in characterization of renal stones chemical composition.

Dual energy computed tomography in this in vitro study could significantly replace the standard computed tomography methods used in the diagnosis of urolithiasis regarding their high accuracy in classifying renal stone compositions. In addition to providing a rapid and non-invasive examination or renal stone and determine its composition.

Current in vitro study has clearly shown that citric acid solution can dissolve calcium containing stones effectively.

We also concluded that using elevated temperature helps in higher dissolution rate as shown in the difference between weight loss and dissolution rate of stone samples in room and core temperature.