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Computed tomography of kidney stones for extracorporeal shock wave lithotripsy

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Abstract—**Methods to predict fragmentation efficiency are still needed for extracorporeal shock wave lithotripsy (ESWL). Imaging studies of kidney stones could be a useful tool to guide ESWL. Artificial and real kidney stones were analyzed using standard clinical CT imaging procedures. The objective was to compare CT image properties of phantom and real kidney stones. Image properties of both groups were compared and show a good agreement between them. These preliminary images will be used to measure CT attenuation coefficients of real and artificial stones and find a relationship between attenuation values and the fragmentation coefficient of renal calculi exposed to shock waves.**

I. INTRODUCTION

Extracorporeal shockwave lithotripsy (ESWL) has been a successful procedure for patients with renal and ureteral calculi [1]. Reliable methods to predict fragmentation efficiency and decide treatment modality are still needed. Effectiveness of ESWL varies with stone size, composition, and location. It is possible to know the composition of the stone before ESWL to predict the number of shockwaves and the energy needed.

Computerized tomography (CT) has been used for this purpose to identify urinary calculi, providing the size and location but also the radiological density [2,3]. Nevertheless, further study is needed to determine correlations between the appearance of renal stones on CT and their susceptibility to lithotripter shock waves. CT attenuation values obtained on pretreatment CT provide much better density discrimination than conventional radiography.

The CT number, also called Hounsfield or attenuation number, is a normalized value of the X-ray absorption coefficient. The attenuation value of renal calculi on axial CT images as a predictor of fragmentation efficiency has been studied; however, because of their varying fragmentation behaviors and physical properties, the use of real calculi for comminution studies is problematic.

One objective of our study was to find the relationship between CT attenuation values and the fragmentation of standardized artificial kidney stones, in order to determine if, from the standpoint of physics, CT numbers can predict fragmentation by ESWL.

II. METHOD AND RESULTS

Spherical 1.54 ± 0.05 g HMT (High Medical Technologies, Kreuzlingen, Switzerland) stone phantoms, cylindrical U-30 kidney stone phantoms obtained from Indiana University, as well as two other artificial stones, made at our laboratory by mixing gypsum cement and Velmix stone (Sybron – Kerr, Michigan) with water, were used. Hounsfield units were obtained on a ZX/I General Electric tomographer. Stones were weighed and exposed to 700 shockwaves at 21 kV at the focus of an electrohydraulic lithotripter.

Fragments were strained through meshes with 2 x 2 mm and 3.1 x 3.1 mm openings. The material left on the meshes after shockwave exposure was dried and weighed. Stones with higher Hounsfield units resulted in lower fragmentation. Mean initial stone weight was inversely proportional to stone fragmentation.

Kidney stones were also used to generate CT images and to test the capabilities of the scanner at the UAM.[1]

Fig. 1. Scanner manufactured by Elscint, model Exel CT Twin, 1996 was installed (2004) at the CIIIM-UAM tomography research laboratory

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Fig. 2. Phantoms and different composition renal calculi are shown. From left to right are HMT spherical phantom, U-30 cylindrical phantom, calcium carbonate-magnesium-xantine real renal calculi, calcium carbonate-magnesium-amonia-colesterol renal calculi, only calcium carbonate renal calculi, phosphate-calcium carbonate-amonia renal calculi.

CT images of phantom and renal stones, shown in Fig. 2, were acquired with the Elscint Exel CT Twin tomographer (shown in Fig. 1). Fig. 3 shows axial slides of three real renal calculi. Fig.4 shows different HMT spherical phantoms axial slides.

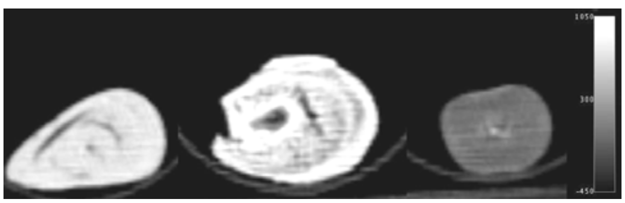

FIG. 3. Human kidney stones showing differences in morphology and composition.

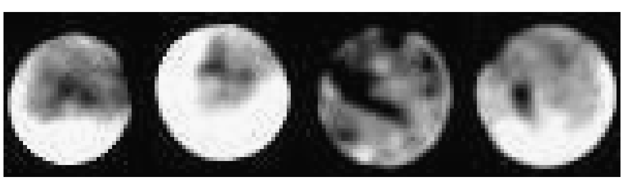

FIG. 4. Spherical HMT stone phantom images showing different composition.

The images of stone and phantoms were acquired to test the Hounsfield measurement differences of both the phantom type and renal calculi stones for this particular application. Figs. 3 and 4 were digitally analyzed using the DICOM transference protocol. All calculations were carried out with the OsiriX visualization software (OsiriX Technologies, Atlanta, The USA) [4]. CT values for phantom and human samples were 141 – 128 HU and 149 – 253 HU, respectively.

I. DISCUSSION

We proved that useful information of both stone phantom and human kidney stones can be obtained with a clinical CT scanner, using standard acquisition parameters. Results show that prediction of the necessary number of shock waves for successful ESWL could be possible. The size of the stones was major concern in this study, since the CT scanner is limited by the resolution of 1 mm.

The reported Hounsfield values were found to be in the same range for both cases, and agree with those reported with the published data. This means that the image acquisition protocols as used in the CT scanner are adequate for the purposes of our preliminary results. Nevertheless, images showed a good quality and offered relevant information on their composition via the Hounsfield units. This implies that image analysis can be used as a tool to study stone properties. Consequently, hospitals with old generation CT scanners could use them to predict ESWL outcome without modifications or new expensive hardware and software.

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