European Journal of Radiology 82 (2013) 1201–1206

Contents lists available at SciVerse ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Pitfalls in urinary stone identification using CT attenuation values: Are we getting the same information on different scanner models?

Romain Grosjean[a,1], Michel Daudon[a,2], Mario F. Chammas Jr.[b,3], Michel Claudon[a,4], Pascal Eschwege[c,5], Jacques Felblinger[a,6], Jacques Hubert[c,*]

[a] IADI Laboratory, INSERM-U947, Nancy-University, Allée du Morvan, 54500 Vandoeuvre-les-Nancy, France
[b] University of Sao Paulo – Division of Urology, Av. Dr. Enéas de Carvalho Aguiar, 255, 7º Andar – s. 7123, São Paulo, Brazil
[c] Department of Urology, Brabois Hospital, University Hospital of Nancy, Allée du Morvan, 54511 Vandoeuvre-les-Nancy, France

ARTICLE INFO

Article history:
Received 26 November 2012
Received in revised form 20 January 2013
Accepted 7 February 2013

Keywords:
Urinary Stones
CT Scanner
Chemical characterization
Chemical composition

ABSTRACT

Introduction: Evaluate the capability of different Computed Tomography scanners to determine urinary stone compositions based on CT attenuation values and to evaluate potential differences between each model.
Methods: 241 human urinary stones were obtained and their biochemical composition determined. Four different CT scanners (Siemens, Philips, GEMS and Toshiba) were evaluated. Mean CT-attenuation values and the standard deviation were recorded separately and compared with a *t*-paired test.
Results: For all tested CT scanners, when the classification of the various types of stones was arranged according to the mean CT-attenuation values and to the confidence interval, large overlappings between stone types were highlighted. The *t*-paired test showed that most stone types could not be identified. Some types of stones presented mean CT attenuation values significantly different from one CT scanner to another. At 80 kV, the mean CT attenuation values obtained with the Toshiba Aquilion were significantly different from those obtained with the Siemens Sensation. On the other hand, mean values obtained with the Philips Brilliance were all significantly equal to those obtained with the Siemens Sensation and with the Toshiba Aquilion. At 120 kV mean CT attenuation values of uric acid, cystine and struvite stones obtained with the Philips model are significantly different from those obtained with the Siemens and the Toshiba but equal to those obtained with the GE 64.
Conclusions: According to our study, there is a great variability when different brands and models of scanners are compared directly. Furthermore, the CT scan analysis and HU evaluation appears to gather insufficient information in order to characterize and identify the composition of renal stones.

1. Introduction

Urolithiasis remains a common source of acute distress, associated with significant morbidity to patients due to urinary obstruction. According to contemporary data the incidence of urinary stone has been rising over the last years, with a lifetime risk between 6% for women and 12% for men in the United States, and relapse in 50%–70% of patients [1,2].

Key factors in the management of these patients remain the location, size and chemical composition of the stone .The ability to predict its composition before treatment enables the urologist to select the appropriate therapy, usually consisting of surgical or endoscopic management, Shock Wave Lithotripsy (SWL) and medical treatment [3–5]. Additionally, knowing the composition of these stones can also be useful to predict their fragility [6]. Previous reports have described that brushite, cystine, and calcium oxalate monohydrate stones are usually more resistant to fragmentation compared to other stones [5].

Nowadays non-contrast enhanced helical Computed Tomography (CT) is recognized as the most accurate method for detection of calculi in the urinary tract with a reported sensitivity of 94% and a specificity of 97% [7] it has also been accepted as the imaging modality of choice to differentiate between urinary calculi and other pathologic processes, such as blood clots or tumors since

* Corresponding author. Tel.: +33 3 83 15 36 94.
E-mail addresses: r.grosjean@chu-nancy.fr (R. Grosjean), michel.daudon@tnn.aphp.fr (M. Daudon), mariochammas@usp.br (M.F. Chammas Jr.), m.claudon@chu-nancy.fr (M. Claudon), peschwege@yahoo.com (P. Eschwege), j.felblinger@chu-nancy.fr (J. Felblinger), j.hubert@chu-nancy.fr (J. Hubert).
1 Tel.: +33 3 83 15 79 02.
2 Tel.: +33 1 56 01 67 75.
3 Tel.: +55 61 86458644.
4 Tel.: +33 3 83 15 79 02.
5 Tel.: +33 3 83 15 31 61.
6 Tel.: + 33 3 83 15 49 76.

0720-048X/$ – see front matter
http://dx.doi.org/10.1016/j.ejrad.2013.02.020

Table 1
Repartition of the different types of the calculi used for the in vitro study.

Stone types	Quantity
Brushite (calcium hydrogen phosphate dehydrate)	12
Cystine	64
Struvite (magnesium ammonium phosphate hexahydrate)	29
Uric acid	38
Whewellite (calcium oxalate monohydrate)	63
Weddellite (calcium oxalate dihydrate)	35
Total	241

urinary stones have a significantly higher CT attenuation than the surrounding soft tissues and are virtually always visible on unenhanced CT scans.

Early CT studies using a single energy technique have shown that the attenuation of stones in CT may provide some information about their composition [8]. More recently dual-source CT scanners have gained acceptance in the evaluation of nephrolithiasis [4] potentially enhancing the characterization of renal stone composition beyond the capability of consecutive single-energy multidetector CT acquisitions [9].

On the other hand, a limitation that appears to be present in a significant number of the previous studies remains in the fact that usually a single CT scanner is used in the research protocols. Whether if there are significant disparities between different brands and models of scanners in the evaluation of renal stones remains an unanswered question.

To our knowledge, no studies have been conducted to evaluate potential diversities between different scanner models on the evaluation and identification of urinary stones. The aim of our study was to determine, using CT attenuation values, the chemical composition of human renal stones in a jelly phantom and to analyze, in a direct comparison, the differences between 4 different Computed Tomography scanner models.

2. Materials and methods

2.1. Urinary stones

Two hundred and forty one (241) human urinary stones were obtained from the data base of a stone-analysis laboratory (CRISTAL Laboratory, Paris, France). They have been collected during surgical and endoscopic interventions. Their biochemical composition was determined by stereomicroscopy and infrared spectrophotometry, which generated the percentages of the predominant component. The percentage of pure and mixed stones that was obtained and demonstrated that almost two thirds of calculi were polycrystalline. The stones were classified according to their main component and only stones containing at least 85% of one component were used for our study. According to their predominant component, the stones were divided into six different groups: uric acid, cystine, magnesium ammonium phosphate hexahydrate (struvite), calcium oxalate dihydrate (weddellite) (C2), calcium oxalate monohydrate (whewellite) (C1) or brushite (calcium hydrogen phosphate dihydrate) (Table 1). The diameter of the stones varied from 7 to 25 mm (mean size 12 mm).

2.2. Phantom

The stones were placed in a jelly made of water, iodine and animal proteins (Fig. 1). The iodine and proteins concentrations were empirically chosen to assure the jelly a X-ray attenuation similar to that of the human kidney (30 Hounsfield Units (HU) at 120 kV). For one liter of water, we added 21.6 g of animal proteins and 0.01 mg of iodine. Each layer of jelly, containing all the stones of a similar type, was successively settled in a plastic container (280 × 210 × 110 mm). The jelly phantom was homogeneous (30 HU ± 3). Stones were embedded in a 3 cm thickness layer. The jelly phantom included 6 layers for a total thickness of 18 cm. The plastic container was then placed in a water tank (Fig. 1).

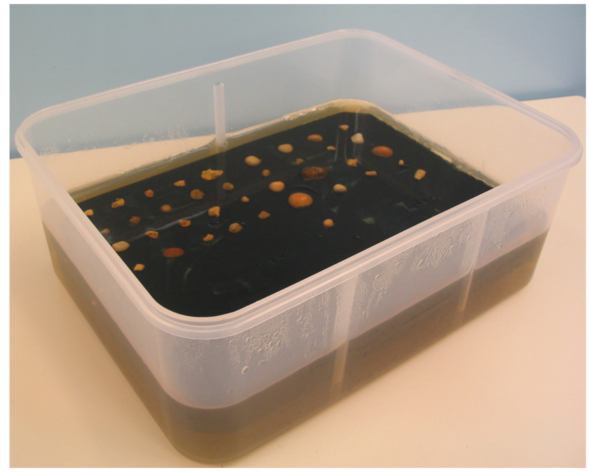

Fig. 1. Stones placed in the jelly.

2.3. CT parameters

Four different CT scanners were evaluated. The parameters applied were those used in a typical abdominal examination protocol in each scanner.

A Somatom Sensation 16 (Siemens, Erlangen, Germany) study was performed with 80 and 120 kV, 200 mAs with a 0.5 s gantry rotation time, a 0.75 mm slice thickness, a 0.7 mm reconstruction index and a 0.8 factor pitch.

A Brilliance VCT (Philips Healthcare, Eindhoven, The Netherlands) study was performed with 80 and 120 kV, 200 mAs with a 0.5 s gantry rotation time, a 0.625 mm slice thickness, a 0.5 mm reconstruction index and a 0.981 factor pitch.

A Lightspeed VCT (GEMS, Milwaukee, USA) study was performed with 80 and 120 kV, 200 mAs with a 0.67 s gantry rotation time, a 0. 5 mm slice thickness, a 0.5 mm reconstruction index and a 0.891 factor pitch.

An Aquilion one (Toshiba Medical, Zoetermeer, The Netherlands) study was performed with 80 and 120 kV, 200 mAs with a 0.5 s gantry rotation time, a 0. 5 mm slice thickness, a 0.5 mm reconstruction index and a 0.828 factor pitch.

2.4. Image analysis

For the CT-attenuation values measurement, a homemade interface based on Matlab™ (Mathworks, Ma, USA) permitted image analysis. Stones were segmented from MPRs (Multiplanar Reconstruction) using standard morphological image processing operations by use of standard morphologic image-processing operations (global threshold of 155 HU, opening to remove pixel inferior in relation to three pixels and closing to gather the contiguous zones separated by the thresholding). For each acquisition and for each stone, the largest region of interest (ROI) was set closest to the largest area of the stone (Fig. 2).

The size and the position of the ROIs have been validated twice by an experienced radiologist using a conventional soft-tissue window. The mean CT-attenuation values and the standard deviation were recorded in Hounsfield Units within the ROI maintaining the conventional soft-tissue window (window width 350 HU; level 40 HU).