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ORIGINAL ARTICLE

Radiological determination of stone density and skin-to-stone distance—Can it predict the success of extracorporeal shock wave lithotripsy?☆

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Abstract
Objectives: To determine the role of stone density and skin-to-stone distance (SSD) by non-contrast computed tomography of the kidneys, ureters and bladder (CT-KUB) in predicting the success of extracorporeal shock wave lithotripsy (ESWL).
Methods: We evaluated 89 patients who received ESWL for renal and upper ureteric calculi measuring 5—20 mm, over a 12 month period. Mean stone density in Hounsfield units (HU) and mean SSD in millimetres (mm) was determined on pre-treatment CT-KUB at the CT workstation. ESWL was successful if post-treatment residual stone fragments were $\leq$3 mm.
Results: ESWL success was observed in 68.5% of the patients. Mean stone densities were 505 ± 153 and 803 ± 93 HU in ESWL successful and failure groups, respectively; this was statistically significant ($p < 0.001$, student's *t*-test). Mean SSD were 10.6 ± 2.0 and 11.2 ± 2.6 cm in ESWL successful and failure groups, respectively, this was not statistically significant.
Conclusions: This study shows that stone density can help in predicting the outcome of ESWL. We propose that stone densities <500 HU are highly likely to result in successful ESWL. Conversely, stone densities $\geq$800 HU are less likely to do so. This should be accounted for when considering ESWL.

Abbreviations: CT-KUB, non-contrast computer tomography of kidney, ureter and bladder; HU, Hounsfield units; ESWL, extracorporeal shock wave lithotripsy; SSD, skin-to-stone distance.

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Introduction

Increasingly, the primary radiological imaging modality used for urinary lithiasis is CT-KUB [1]. Its higher sensitivity in detecting small, radiolucent calculi with the avoidance of intravenous contrast media, are the principle factors responsible for replacing the traditional intravenous urography [2,3]. ESWL was introduced in the 1980s and today represents one of the most frequently used methods in the treatment of urinary upper tract calculi [4,5]. The outcome governing the success of ESWL is dependent on a number of factors which include stone consistency, size, shape and location [4]. Recently, a few studies have attempted to correlate the radiological findings on pre-treatment CT-KUB with ESWL outcomes [6—9]. We evaluated the role of stone density and SSD in predicting the success of ESWL treatment.

Methods

A retrospective study was carried out for patients who underwent ESWL for renal and upper ureteric calculi between April 2005 and March 2006 at our tertiary referral unit. Case notes were reviewed of patients that fulfilled the inclusion criteria. These criteria were; calculi measuring between 5 and 20 mm in patients who had undergone a pre-treatment CT-KUB and were also radio opaque on pre-treatment plain abdominal film. Patients who had not had a pre-treatment CT-KUB or had a ureteric stent, nephrostomy tube and/or steinstrasse were excluded. All patients had a CT-KUB with a helical CT scanner (Hi-Speed CTi, General Electric, Milwaukee, USA). The images were obtained using high quality mode at 200—240 mA, 120 kV and 5 mm collimation reconstructed at 3.75 mm. Determination of stone density and skin-to-stone distance was carried out at the CT workstation by the radiology specialist registrar. For the measurement of stone density, axial planes were defined for each stone. In each plane, an area of interest smaller than the stone was created; the stone density was recorded in HU, the mean value of the three readings was calculated (Fig. 1). The SSD recorded in mm was calculated as the mean value of three measured distances between the centre of the stone and skin (0°, 45° and 90°) using radiographic callipers (Fig. 2). All patients received 4000 shock waves with a Siemens Lithostar Multiline Lithotripter (Germany). Stones were fragmented under fluoroscopic/ultrasound guidance. A post-treatment plain abdominal film was used to assess fragmentation of ureteric and renal calculi at ≤2 or ≤6 weeks, respectively (plain films were reported by the consultant radiologist). If residual renal stone fragments were ≤3 mm (for ureteric stones—total clearance), patients were considered to have achieved clinically successful ESWL outcomes [6]. Statistical analysis was performed with Student's *t*-test and Pearson's correlation using Minitab version 15.

Figure 1 Axial image of non-contrast computer tomography showing a 14 mm left renal pelvis stone. The stone density is 976 HU determined within the region of interest (◌).

Results

Of the 105 patients who underwent ESWL, 89 patients fulfilled the study criteria. Patient characteristics are shown in Table 1. Approximately two-thirds of the patients were male. Overall, the mean age (years) of the patients was 52 (range 19—85). Calculi were equally distributed between the upper ureter ($n = 44$) and kidney ($n = 45$), in the

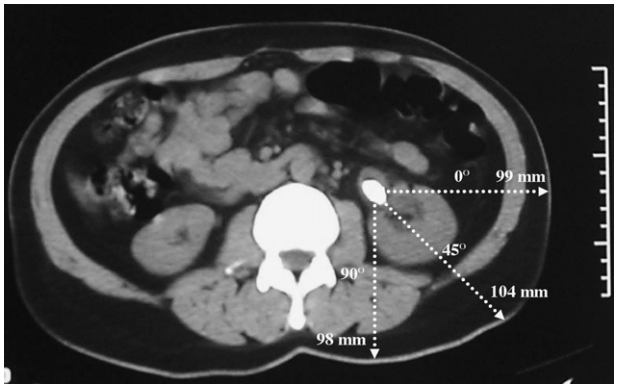

Figure 2 Axial image of non-contrast computer tomography showing a 14 mm left renal pelvis stone. The skin-to-stone distance measurements were 99, 104 and 98 mm at 0°, 45° and 90°, respectively.