The usefulness of stone density and patient stoutness in predicting extracorporeal shock wave efficiency: Results in a North African ethnic group

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Abstract

Introduction: We 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 to 20 mm, over a 12-month period. The mean stone density in Hounsfield units (HU) and mean SSD in mm was determined on pre-treatment CT-KUB at the CT workstation. ESWL was successful if post-treatment residual stone fragments were ≤3 mm.
Results: ESWL success was observed in 68.5% of patients. Mean stone densities were 505 ± 153 and 803 ± 93 HU in the ESWL successful and failure groups, respectively ($p < 0.001$, student's t-test). The 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 to predict the outcome of ESWL. We propose that stone density <500 HU are highly likely to result in successful ESWL. Conversely, stone densities >800 HU are less likely to be successful.

Introduction

Increasingly, the primary radiological imaging modality used for urinary lithiasis is computed tomography of the kidneys, ureters and bladder (CT-KUB).[1] Its higher sensitivity in detecting small, radiolucent calculi with the avoidance of intravenous contrast media is principally responsible for replacing the traditional intravenous urography.[2,3] ESWL was introduced in the 1980s and represents one of the most frequently used methods to treat 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] Few studies have attempted to correlate the radiological findings on pre-treatment CT-KUB with ESWL outcomes.[6-9] We evaluate 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 2008 and March 2011 at our tertiary referral unit. Patient case notes were reviewed. The inclusion criteria were: calculi measuring between 5 and 20 mm in patients who had undergone a pre-treatment CT-KUB and who were also radio-opaque on pre-treatment plain abdominal film. Patients who did not have a pre-treatment CT-KUB or 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, WI). The images were obtained using high quality mode at 200 to 240 mA, 120 kY and 5 mm collimation reconstructed at 3.75 mm. Determination of stone density and skinto-stone distance was carried out at the CT workstation by the radiologist. 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 and the mean value of the 3 readings was calculated. The SSD recorded in mm was calculated as the mean value of 3 measured distances between the centre of the stone and skin (0°, 45° and 90°) using radiography callipers. All patients received 4000 shock waves with a Siemens Lithostar Multiline Lithotripter (Germany). Stones were fragmented under f1uoroscopic/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.

Results

Of the 105 patients who underwent ESWL, 89 patients fulfilled the study criteria (Table 1). About two-thirds of the patients were male. Overall, the mean age (years) was 52 (range: 19-85). Calculi were equally distributed between the upper ureter (n = 44) and kidney (n = 45); in the latter, the number of patients with calculi in the renal pelvis, upper, middle and lower calyces were 13, 11, 7 and 14, respectively.

The overall success of ESWL treatment was observed in 68.5% of the 89 patients (Table 1). Patients with either successful or failed ESWL outcomes had a mean stone density of 506 ± 153 and 803 ± 93 HU, respectively (the results are represented as mean ± standard deviation). The difference was statistically significant ($p < 0.001$). This difference was significant regardless of location of calculi. Furthermore, patients with a mean stone density <500 and >800 HU had 100% and 32% successful ESWL outcomes, respectively. Patients with a mean stone density between 500 and 799 HU had 69% successful outcomes. There was a weak correlation between mean stone density and the number of ESWL sessions needed for successful treatment (Pearson's correlation, r = 0.53).

There was no significant difference seen when the effect of SSD and ESWL outcome was studied ($p < 0.26$). Patients who underwent ESWL with either successful or failed outcomes had a mean SSD of 10.6 ± 2.0 and 11.2 ± 2.6 cm, respectively.

Of the 28 patients who failed ESWL treatment, 24 went on to have endourological intervention. Ureteroscopy and fragmentation were done in 22 patients. Percutaneous nephrolithotomy (PCNL) was performed in 2 patients with calculi measuring 15 and 20 mm. Conservative treatment was employed in 4 patients with renal calculi, 3 of whom were asymptomatic and 1 was considered high-risk for intervention.

Table 1 Characteristics and ESWL outcome.

Characteristics	ESWL successful	ESWL failure
Patient, no.	61	28
Sex, no. male	46	16
Sex, no. female	15	12
Mean age, years	51	53
Mean stone size, mm	7.5	9.2
Mean stone density (HU)	505 ± 153	803 ± 93
Mean stone density* >800 HU	32 (8)	68 (17)
Mean stone density* 500-799 HU	69 (24)	31 (11)
Mean stone density* <500 HU	100 (29)	0 (0)
Mean skin-to-stone distance, cm	10.6 ± 2.0	11.2 ± 2.6

* Expressed as % (no. patients). ESWL: extracorporeal shock wave lithotripsy.

Discussion

ESWL is one of the most frequently used modalities to treat upper urinary tract calculi.[4,5] The outcome of ESWL is measured in terms of stone fragmentation and clearance. Failure of ESWL results in unnecessary exposure of renal parenchyma to shock waves and complications; therefore, alternative treatments are needed, incurring additional expense.[10] In our unit, these are estimated at $500 US per ESWL session. A number of stone characteristics, such as fragility, size, location and composition, are known to affect outcome.[11]

Stone fragility correlates with mineral content and stone density.[12] Early work evaluated stone fragility as a predictive factor of ESWL outcome. Chaussy and colleauges[13] suggested that a stone was less likely to break if its density was greater than that of vertebral spine on a plain abdominal film. Mattelaer and colleauges[14] concluded that highly opaque stones were less fragile with ESWL therapy. Others have shown that smooth, uniform stones that appeared denser than bone (12th rib) on a plain abdominal film responded poorly to ESWL.[11] The main limitation of these studies was their subjective nature of assessment; therefore, they have not progressed widely into clinical practice.

CT-KUB of the renal tract has emerged as the first-line radiological imaging modality for patients with acute ureteric colic.[1,15] The determination of stone density obtained on CT-KUB is easy, objective, reliable and reproducible.[16] This has recently led to a re-evaluation of stone fragility as a predictive factor for ESWL outcomes by determining stone density measured on the pre-treatment CT-KUB.[6-9] We investigated the role of stone density and SSD as factors predicting the outcome of ESWL. Few stones are composed of a single material.[17] Given the variability of stone densities within the same stone,[18] we determined the mean stone density of three separate readings within the same stone. The results of our study show that a mean stone density ≥800 HU is a predictor of ESWL failure. This supports the work of Wang and colleagues[9] who concluded that stone densities >900 HU were significant predictors of ESWL failure. Others have recommended different stone densities, namely >750 HU[7] and >1000 HU.[8] We invariably found that a mean stone density <500 HU resulted in successful treatment. Pareck and colleagues[6] found successful outcomes in 74% of patients with a stone density <500 HU. The difference in stone density cut-off values may be a result of the different criteria used in CT protocols and end points to define successful ESWL outcome. A limitation of this retrospective study was that different radiological imaging modalities were used to determine stone size in pre- and post-ESWL treated patients. This raises the possibility of introducing error in post-treatment estimation of stone size and stone burden. Although a post-treatment CT-KUB would have been desirable, it would only have been justifiable in the context of a prospective clinical study, similar to the study by Wang and colleagues.[9] Despite the limitations, the results of our work and others are promising. Further evaluation of this correlation needs to be clarified with a standardized CT-KUB protocol and clearly defined end points in a multicentre prospective randomized controlled trial.

Furthermore, unlike the work of Pareek and colleagues,[19] when we analyzed the effect of SSD and successful ESWL outcomes, our study failed to show a statistical difference. However, we view our result with caution given that Pareek and colleagues specifically looked at patients with lower pole stones and the study numbers were larger.

The weak correlation between mean stone density and the number of ESWL sessions needed (r = 0.53) has also been shown by other investigators.[8] However, Joseph and colleagues[20] found a positive correlation. A likely explanation for this conflicting finding may be due to the use of low-resolution collimation by Joseph and colleauges,[20] which yielded low stone density values for small stones.

Conclusion

Our findings show that the determination of HU stone density on pre-treatment CT-KUB can predict the success of ESWL for upper ureteric and renal calculi measuring 5 to 20 mm. Furthermore, the success is independent of stone location, whether in the upper ureter or kidney. We have observed that a mean stone density <500 HU is highly likely to result in successful ESWL outcome. Conversely, a mean stone density ≥800 HU is less likely to result in success. The value of stone density may aid in selecting patients for ESWL and thus improving the efficacy of ESWL.

Competing interests: Dr. Abdelaziz, Dr. Elabiad, Dr. Aderrouj, Dr. Janane, Dr. Ghadouane, Dr. Ameur and Dr. Abbar all declare no competing financial or personal interests.

This paper has been peer-reviewed.

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