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ORIGINAL ARTICLE

The success of extracorporeal shock-wave lithotripsy based on the stone-attenuation value from non-contrast computed tomography

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Urinary calculi;
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BMI;
ESWL;
Lower calyceal stone

ABBREVIATIONS

SAV, stone-attenuation value;
HU, Hounsfield unit;
NCCT, non-contrast computed tomography;
BMI, body mass index;

Abstract ***Objective:*** To determine the utility of the urinary stone-attenuation value (SAV, in Hounsfield units, HU) from non-contrast computed tomography (NCCT) for predicting the success of extracorporeal shock-wave lithotripsy (ESWL).

Patients and methods: The study included 305 patients with renal calculi of ⩽30 mm and upper ureteric calculi of ⩽20 mm. The SAV was measured using NCCT. Numerical variables were compared using a one-way analysis of variance with posthoc multiple two-group comparisons. Univariate and multivariate regression analysis models were used to test the preferential effect of the independent variable(s) on the success of ESWL.

Results: Patients were grouped according to the SAV as group 1 (⩽500 HU, 81 patients), group 2 (501–1000 HU, 141 patients) and group 3 (> 1000 HU, 83 patients). ESWL was successful in 253 patients (83%). The rate of stone clearance was 100% in group 1, 95.7% (135/141) in group 2 and 44.6% (37/83) in group 3 ($P = 0.001$).

Conclusions: The SAV value is an independent predictor of the success of ESWL and a useful tool for planning stone treatment. Patients with a SAV ⩾956 HU are

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US, ultrasonography; ROC, receiver operating characteristic (curve)

not ideal candidates for ESWL. The inclusion criteria for ESWL of stones with a SAV < 500 HU can be expanded with regard to stone size, site, age, renal function and coagulation profile. In patients with a SAV of 500–1000 HU, factors like a body mass index of > 30 kg/m^2 and a lower calyceal location make them less ideal for ESWL.

Introduction

Currently ESWL is the treatment of choice for most renal calculi ⩽30 mm, with success rates of 60–99% [1–3]. The failure of ESWL results in wasted medical costs, deterioration in patients with obstructed kidneys, unnecessary exposure to ionising radiation and to shock waves. Hence, it is desirable to distinguish those patients who would benefit from ESWL from those who need an alternative treatment.

Several studies concluded that the outcomes of ESWL correlate with several factors, including stone size, location, renal and calyceal anatomy, body mass index (BMI), stone composition, and recently the stone-attenuation value (SAV) [4–7]. Thus we evaluated whether the SAV of urinary calculi on non-contrast CT (NCCT), measured as Hounsfield units (HU) can be used as an independent predictor of calculus fragmentation by ESWL.

Patients and methods

Between June 2009 and October 2011, and with approval of the ethics board committee, 305 patients with a solitary renal or upper ureteric stone were treated by ESWL, using an electrohydraulic lithotripter, in a prospective study at the Beni-Suef University Hospital, Egypt.

An *a priori* power analysis used to calculate the sample size (Stats Direct version 2.7.2, Cheshire, UK), with the difference in the success rate of ESWL according to the SAV considered to be the principal study outcome. The calculation was based on comparing two proportions from independent samples using the chi-squared test, the α-error level was fixed at 0.05 and the power was set at 95%. The lowest ESWL success rate was ≈77%, and accordingly the optimum sample size was calculated to be ⩾81 patients in each arm to be able to detect a minimally important difference in the success rate of 20%.

The patients comprised 184 men and 121 women, aged 20–63 years, with either a renal stone ⩽3 cm (pelvic or calyceal) or an upper ureteric stone ⩽2 cm. Patients had radio-opaque stones and a normal renal anatomy. Patients with upper urinary tract stones > 3 cm, an abnormal renal anatomy, morbid obesity (BMI ⩾ 40 kg/m^2), renal insufficiency, distal obstruction, uncontrolled coagulopathy, uncontrolled hypertension, renal artery or aortic aneurysm, an active UTI or pregnancy were excluded from the study.

All patients were evaluated by a complete history and physical examination, urine analysis, urine culture, coagulation profile, complete blood count, and serum creatinine level. Imaging included abdomino-pelvic ultrasonography (US), a plain abdominal film, and NCCT with slices every 3 mm to measure the highest mean SAV and size of the stone.

The SAV was measured from three axial NCCT slices for each stone, i.e., one at the level of the stone's maximum diameter, and one above and one below nearer to both poles of the stone. In each image, a circle was drawn inside the stone perimeter and the SAV was measured, with the highest value recorded.

All patients were treated by ESWL using an electrohydraulic lithotripter (using a spark-gap system with ellipsoidal focus, X-ray fluoroscopy localisation, a focal pressure of 55–110 MPa, focal point dimensions of 2.40 × 0.6 cm, a focal distance of 13.5 cm, and a shock-wave frequency of 30–120/min).

All patients were treated while supine and by one urologist, and received intravenous analgesia in the form of 1 mg/kg meperidine hydrochloride and intravenous fluids throughout the procedure. Shock waves were not synchronised with the patient's electrocardiogram. The power was increased from 6 to 22 kV, using a standardised protocol (500 shock waves up to 10 kV, 500 up to 14 kV, 1000 up to 18 kV, and 500 up to 22 kV), with a frequency of 60 shocks/min. The session was stopped when the machine's upper limit of shock waves per session (2500) was reached.

Patients were followed up at 1 week after ESWL with a plain abdominal film and US. If there were significant fragments a second session of ESWL was planned. However, if there were only insignificant fragments the patients were given medical treatment and re-evaluated after 1 month. The final results were considered after the complete passage of all fragments or after 3 months from the last ESWL session.

The outcome of ESWL was described as a success or failure, where success included stone-free, i.e., complete stone clearance, or clinically insignificant residual fragments < 4 mm with no symptoms at 3 months after ESWL. Failure was defined as residual stone fragments, i.e., clinically significant residual fragments ⩾4 mm after three sessions of ESWL, as confirmed by a plain film, or in patients with no evidence of fragmentation