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ORIGINAL ARTICLE

Noncontrast computed tomography can predict the outcome of shockwave lithotripsy via accurate stone measurement and abdominal fat distribution determination

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Abstract Urolithiasis is a common disease of the urinary system. Extracorporeal shockwave lithotripsy (SWL) has become one of the standard treatments for renal and ureteral stones; however, the success rates range widely and failure of stone disintegration may cause additional outlay, alternative procedures, and even complications. We used the data available from noncontrast abdominal computed tomography (NCCT) to evaluate the impact of stone parameters and abdominal fat distribution on calculus-free rates following SWL. We retrospectively reviewed 328 patients who had urinary stones and had undergone SWL from August 2012 to August 2013. All of them received pre-SWL NCCT; 1 month after SWL, radiography was arranged to evaluate the condition of the fragments. These patients were classified into stone-free group and residual stone group. Unenhanced computed tomography variables, including stone attenuation, abdominal fat area, and skin-to-stone distance (SSD) were analyzed. In all, 197 (60%) were classified as stone-free and 132 (40%) as having residual stone.

Conflicts of interest: All authors declare no conflicts of interest.

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The mean ages were 49.35 ± 13.22 years and 55.32 ± 13.52 years, respectively. On univariate analysis, age, stone size, stone surface area, stone attenuation, SSD, total fat area (TFA), abdominal circumference, serum creatinine, and the severity of hydronephrosis revealed statistical significance between these two groups. From multivariate logistic regression analysis, the independent parameters impacting SWL outcomes were stone size, stone attenuation, TFA, and serum creatinine. [Adjusted odds ratios and (95% confidence intervals): 9.49 (3.72−24.20), 2.25 (1.22−4.14), 2.20 (1.10−4.40), and 2.89 (1.35−6.21) respectively, all $p < 0.05$]. In the present study, stone size, stone attenuation, TFA and serum creatinine were four independent predictors for stone-free rates after SWL. These findings suggest that pretreatment NCCT may predict the outcomes after SWL. Consequently, we can use these predictors for selecting the optimal treatment for patients with urinary stones.

Introduction

Extracorporeal shockwave lithotripsy (SWL) was first introduced in 1980 by Chaussy et al. [1] and was successfully applied to patients with urolithiasis [2]. It has become the standard treatment for renal and ureteral stones <2 cm in diameter. Compared with endourological lithotripsy and open surgeries, SWL is a noninvasive method and has similar stone-free rates in appropriate patients. However, the success rates range from 46% to 91% [3−5] and failure of stone disintegration may cause additional outlay, alternative procedures, and even complications such as stone street and renal hematoma; therefore, to identify patients who will benefit from SWL prior to treatment is important. Further studies have focused on patient demographic characteristics, such as age, stone location, stone size, hydronephrosis, and serum creatinine level, as possibly influencing the stone-free rate following SWL [6−8].

Recently, it has been suggested that abdominal obesity, body mass index (BMI), waist circumference, and waist-to-hip circumference ratio may be related to the stone-free rate of SWL [9,10]. A previous study evaluated 100 patients who had undergone SWL for 5−10-mm upper urinary tract stones, and the authors found that BMI and Hounsfield unit (HU) density were significant independent predictors of calculus-free rates [10]. Another study surveyed 111 patients with renal stones receiving SWL, and the result showed that calculus attenuation and skin-to-stone distance (SSD) could predict SWL success [11]. Both of them revealed that body fat might be an important factor regarding the success rate of SWL.

Noncontrast abdominal computed tomography (NCCT) has long been used for the evaluation of urinary calculus. Compared with plain radiography, ultrasonography, and excretory urography, NCCT can provide rapid and accurate determination of stone parameters. Besides, NCCT can be used for the accurate assessment of intra-abdominal fat and it is considered to be the optimal method over other anthropometric measurements, such as BMI or waist circumference [12]. In addition, many studies have proven that total fat area (TFA), visceral fat area (VFA), and subcutaneous fat area (SFA) from NCCT obtained at the level of L4 and L5, closely correlated with the volume of abdominal fat [13−15]. Thus, we used the data available from NCCT to evaluate the impact of stone parameters and abdominal fat distribution on calculus-free rates following SWL.

Material and methods

From August 2012 to August 2013, 328 consecutive patients who underwent SWL for urinary calculi with a size between 5 mm and 20 mm were reviewed retrospectively at a single medical center. Ethical approval by the Institutional Review Board of Kaohsiung Medical University Hospital, Kaohsiung, Taiwan was obtained for data collection and analysis. Of the 328 patients, 207 were men and 121 were women. All patients underwent plain kidney, ureteric, and bladder (KUB) radiography and NCCT prior to SWL. All of them were shown to have a radiopaque calculus. Thorough demographic data, clinical history, physical examination, urine analysis, radiographic study, and sonography were recorded prior to SWL. The characteristics of calculus, such as calculus location, calculus size (maximum calculus length), calculus laterality, and calculus surface area, were collected by KUB radiography. Other stone profiles (in HU), skin-to-stone distance (SSD), abdominal fat distribution parameters (SFA, VFA, TFA), and para- and perirenal fat area were determined from NCCT by a radiologist who was blinded to the clinical details of the patients.

Unenhanced computed tomography (CT) of the abdomen was performed with spiral CT acquisition (GE Healthcare, Milwaukee, WI, USA) using 0.5-cm collimation from the upper border of kidneys to the pubic symphysis with 0.25-cm reconstruction. To measure the stone density in HU, we used the greatest diameter of the stone on the cross-sectional CT image for analysis as Perks et al. described previously [11]. A total of three coherent, nonoverlapping regions of interest (area 0.01 cm^2) would be chosen to calculate the mean attenuation (Fig. 1A). To measure the SSD, three distances were collected on axial CT from the center of the stone to the skin surface—perpendicular, horizontally, and at 45° between the first two measurements (Fig. 1B) [11].

The data of abdominal fat distribution, such as TFA, VFA, and SFA, was collected by using the methods described by Yoshizumi et al. [16]. VFA and SFA were measured on one