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ORIGINAL PAPER

Feasibility and efficacy of extracorporeal shock-wave lithotripsy using a new modified lateral position for the treatment of renal stones in obese patients

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Abstract The aim of our study was to evaluate the efficacy and safety of ESWL using a modified lateral position in obese patients with renal stones. Nineteen obese patients with renal stones were enrolled (group A). The mean stone diameter was 1.3 cm (0.7–1.9 cm). The mean BMI was 35.1 kg/m^2 (31–41 kg/m^2). Patients were placed in the lateral position, with the energy source facing their body posteriorly and the site where the stone was located in direct contact with the water cushion. Success rate (defined as the percentage of patients who were stone-free or with insignificant fragments after 3 months), mean number of ESWL sessions, mean duration of ESWL session and complications were recorded. The results were compared with those of 17 obese patients (Group B) with similar baseline characteristics treated in the standard supine position. All ESWLs were performed using the Dornier lithotripter SII. Both success rate (68.4 vs. 64.7% for groups A and B, respectively) and mean number of sessions (2.2 vs. 2.6) did not differ significantly between the two groups ($p = 0.5$). Interestingly, the time required to complete ESWL was significantly shorter for group A patients (56 min) compared to group B (73 min) ($p = 0.001$). No severe complications (including hematoma, pyelonephritis) were recorded. Our data indicate that ESWL in the modified lateral position for renal calculi in obese patients seems to be feasible and safe. In addition, it is faster than in the supine position since it overcomes technical difficulties. Further studies with a large number of patients are required to support our findings.

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Introduction

Obesity and weight gain are associated with an increased risk of kidney stone formation. Defining obesity as a body mass index (BMI) of >30 kg/m^2, the recent epidemiological studies indicate that obese patients suffer from urolithiasis twice as much as the non-obese [13, 18, 20]. Since the prevalence of obesity has increased by more than 75% since 1980 [8], it is evident that urologists will face an increasing number of obese and morbidly obese patients suffering from nephrolithiasis who will seek adequate treatment.

Extracorporeal shock-wave lithotripsy (ESWL) for the management of renal lithiasis in obese patients is associated with several problems that should be overcome to reach an acceptable success rate [3]. From technical aspects, focusing on the stone, either radiographically or ultrasonographically, may be extremely difficult, since body fat may hamper visualization of the stone. In addition, the skin-to-stone distance may be longer than the focal length of the lithotripter, thus decreasing the success rates while increasing the risk of damaging adjacent organs [15]. Interestingly, the greater the body size, the more frequent the collisions of the operating table with the energy source, making the procedure extremely time consuming.

Additionally, studies have shown that BMI is an independent predictor of the ESWL effect [5, 14]. In fact, an inverse relationship between BMI and the ESWL outcome was found, questioning the role of ESWL in obese patients with large renal stones. The proposed scenario for the

reasons of failure might be the shock-wave attenuation due to body fat, which reduces the fragmentation efficacy [2].

Theoretically, the proper positioning of the obese patient on the surgical table, to decrease both skin-to-stone distance and shock-wave attenuation by body fat, may play a critical role for the improvement of the ESWL outcome. In addition, our experience with frequent collisions of the water cushion with the operating table in obese patients led us to reconsider the positioning of the patients on the lithotripsy table. For these reasons, we evaluated the efficacy and safety of ESWL using a modified lateral position in obese patients with renal stones.

Patients and methods

Obese patients (BMI greater than 30 kg/m^2) with a unilateral, less than 2 cm, single, radiopaque stone in the renal pelvis were enrolled in our study. Nineteen consecutive patients (12 men and 7 women, group A) were treated in the modified lateral position, with the shock-wave generator facing their body posteriorly and the site where the stone was located in direct contact with the water cushion (Fig. 1).

The maximum diameter of stone was measured on plain KUB X-ray. Pre-SWL routine investigation included complete blood count, serum creatinine, prothrombin time, activated partial thromboplastin time, urine analysis and culture. In addition, all patients were assessed with an intravenous urography (IVU), ultrasonography or computed tomography (CT) prior to SWL. Patients with anatomical abnormalities or positive urine culture were excluded from our study. ESWL was performed using the electromagnetic shock-wave source EMSE 220 F-XP of Dornier lithotripter SII and stones were fragmented under fluoroscopic guidance. Following the instructions by the manufacturer, none of the patients exceeded 140 kg of weight, so as to ensure that there would not be any damage to the lithotripsy table.

Fig. 1 Patient in the lateral position, with the energy source attached on his back. The stone is located in the right kidney

All patients were treated on an outpatient basis and all lithotripsy sessions were completed without any need for anesthesia. Based on the analgesia protocol of our department [12], intravenous injection of fentanyl citrate at a dose of 0.05 mg was offered to patients when they felt that pain during the session became intolerable. Lithotripsy was recommenced 10 min after administration of analgesia.

Treatment outcome was evaluated by a plain KUB X-ray and renal ultrasonography at 1 month after any SWL session. Success rate was defined as the percentage of patients who were rendered stone-free or had clinically insignificant residual fragments (asymptomatic fragments less than or equal to 3 mm in diameter) after 3 months. Insignificance of residual fragments was evaluated by two of the investigators. The mean number of shock waves delivered, the mean number of sessions, the mean duration of each session and, finally, the complications of the procedure were recorded for each case.

The results of group A were compared with those of 17 obese patients with similar baseline characteristics who had already been treated in the standard supine position before the introduction of the modified lateral position (group B).

The mean number of shock waves delivered, the mean number of sessions, the mean duration of each session and, finally, the complications of the procedure were recorded for both groups.

The study was approved by the Ethics Committee of the University of Thessaly and all participants were informed and gave their consent. Student's t test and χ^2 statistical analysis were used to evaluate the data (SPSS 16.0). A p value less than 0.05 was considered to be statistically significant.

Results

The mean BMI was 35.1 kg/m^2 (31–41 kg/m^2) for group A and 35.3 kg/m^2 (31–42 kg/m^2) for group B and did not differ significantly between groups ($p = 0.9$). The mean stone diameter was 1.3 cm (0.7–1.9 cm) and 1.1 cm (0.8–1.8 cm) for group A and B, respectively ($p = 0.2$). Detailed data of baseline characteristics of patients are presented in Table 1. Furthermore, there was no statistically significance in the number of the shock waves administered between groups. Each patient received a mean of 3,500 shock waves per session (3,000–3,700), with an 80% (70–90%) mean shock-wave intensity ($p = 0.57$).

Thirteen patients in group A (68.4%) and eleven patients in group B (64.7%) had a successful outcome, but the observed success rate did not differ between the two groups

Table 1 Comparison of patients' characteristics, expressed as mean value and range

	Group A	Group B
Patients (*n*)	19	17
Age (years)	49.2 (30–67)	48.8 (27–65)
Gender (male/female)	12/7	9/8
BMI (kg/m^2)	35.1(31–41)	35.3 (31–42)
Stone size (cm)	1.3 (0.7–1.9)	1.1 (0.8–1.8)
Shock waves	3,500 (3,000–3,700)	3,500 (3,000–3,700)

($p = 0.81$). Three patients of group A (15.8%) and four patients of group B (23.5%) presented within the 3-month follow-up with symptomatic, post-lithotripsy hydronephrosis due to residual fragments and underwent ureteroscopy and intracorporeal lithotripsy. At the end of 3 months, the remaining five failures (group A, three cases; group B, two cases) underwent percutaneous nephrolithotomy (PCNL) to achieve stone clearance.

Patients of group A required a smaller number of sessions (2.2) compared to those of group B (2.6), although this difference did not reach statistical significance ($p = 0.5$). Interestingly, time required to complete ESWL was significantly shorter for group A compared to group B (56 vs. 73 min, respectively, $p = 0.001$). This was the only parameter that differed significantly between the two groups.

In general, the procedure was well tolerated. One patient in group A and two patients in group B complained of severe pain during ESWL and received fentanyl citrate intravenously. Furthermore, none of the patients had severe complications (renal hematoma, acute pyelonephritis) and no patient needed to stay at the hospital. Self-limited hematuria, dysuria and pain that responded to oral analgesics were the most common complaints, as expected.

Discussion

Obesity has been associated with increased co-morbidities including ischemic heart disease, diabetes and hypertension, but also with more frequent postoperative complications such as wound infections, atelectasis and thromboembolism [1, 2, 4, 9]. Thus, the management of nephrolithiasis in these patients represents a real challenge for physicians, since both PCNL and ESWL have limitations. Available studies have shown that PCNL in the obese is safe and feasible [6, 10]. However, challenges of PCNL for obese patients include poor visualization, difficulties in identifying anatomic landmarks or reaching the kidney using conventional length instruments and sheaths because of the excess fat tissue, whereas special attention to protecting pressure areas using extra padding may be required. In addition, experienced anesthesiologists and close monitoring are essential for these patients because of their respiratory compromise and decreased venous return.

On the other hand, ESWL plays an important role in the treatment of nephrolithiasis in obese patients, since it is a safe procedure without the need for anesthesia [11, 21]. However, the ESWL efficacy in obese patients is not as high as in non-overweight patients, mainly due to poorer identification of the stone, increased skin-to-stone distance and the shock-wave attenuation by body fat, which has some effect on the efficiency of stone fragmentation [7, 11, 17, 19, 21].

In our study using the modified lateral position, the energy source was placed posteriorly to the patient, aiming at the reduction of the skin-to-stone distance on one hand, exploiting the lithotripter's maximum focal length on the other (Table 2). It is of note that the adipose tissue lies anteriorly, avoiding contact with the generator. The results of the present study suggest that the success rate of stone fragmentation using the modified lateral position (68.4%) was better, although not statistically significant, than the conventional supine position (64.7%). Furthermore, patients treated in the modified position achieved better scores with less SWL sessions (2.2 vs. 2.6, respectively).

It is already known that the skin-to-stone distance (SSD) is an independent predictor of the ESWL outcome in a negative way, such that the longer the distance to the stone, the less is the successful effect of the lithotripsy shock waves. This was first stated by Pareek et al., who measured three SSDs from the center of the calculus to the level of the skin at 0° (vertical), 45° and 90° (horizontal) on non-contrast CT (NCCT) and found that lower pole stones with SSD greater than 10 cm had fewer chances to vanish after a lithotripsy session. In their study, the SSD was in straight relation to the penetration angle of the shock waves; usually, the greater SSD was measured at the 45° angle [15]. Later on, SSD proved to be a predictive factor for all the renal stones irrespective of their location in the kidney [16].

Table 2 Shock-wave parameters at maximal intensity (*EMSE 220F-XP)*

Intensity level (%)	10–120
Focal pressure P_(MPa)	118.2
Focal pressure P (rarefaction) (MPa)	11.7
Focal size	
Lateral (x, y) (mm)	2.6
Axial (z) (mm)	50
Pulse duration (nsec)	300
Rise time (nsec)	80
Effective energy E (12 mm) (mJ)	79.4
Maximum focal length (cm)	14.8

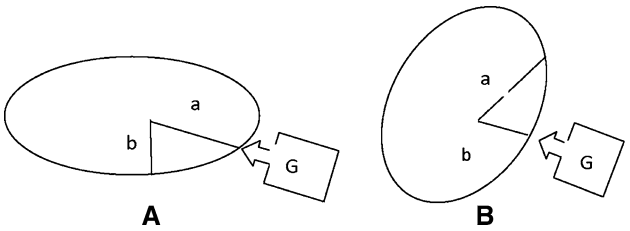

Fig. 2 By rotating the patient on the lithotripsy table (from **A** to **B**), the wave travels a shorter SSD (**b**) than the greater SSD (**a**). G, shock-wave generator

In our study, we used an electromagnetic lithotripter (Dornier SII, EMSE 220 F-XP). The shock-wave generator couples in the axial plane 45° off the vertical axis, which means that the wave has to travel a greater SSD than if the emitter could couple at a 0° angle. Our rationale was then that a shorter SSD could be easily achieved by altering, instead of the position of the generator, the position of the patient on the lithotripsy table, from the conventional supine to the posterior lateral position. In this way, the penetration angle remains the same (45°), but the SSD decreases (Fig. 2). Of note is that we did not estimate the true SSDs on NCCT, since this was not the primary end point of our study.

On the other hand, even if this is the case with electromagnetic lithotripters with large focal points (usually 14–15 cm), things differ in other lithotripters. For electrohydraulic lithotripters, such as the Dornier HM3, the shock wave is generated by an underwater spark discharge from an electrode. This electrode is placed at one focus (termed F1) of an ellipsoid, and the stone is placed at the other focus (termed F2). The focal distance between the F1 and F2 foci for the Dornier HM3 is 13 cm, which is slightly less than the focal distance of the electromagnetic lithotripters. In large or obese patients, the positioning of the target stone at F2 could be extremely hard due to body wall dimensions, emerging the need for technical modifications to overcome procedure difficulties.

Few studies have investigated alternatives to optimize ESWL outcomes in obese patients. Thomas and Cass used abdominal straps to reduce the distance between F1 and F2 focal points and implemented higher power settings to treat a stone in the extended stone pathway without serious complications. The reported stone-free rate for obese patients (weight range from 135 to 181 kg) was 68%, comparable to their rate for non-obese patients [21]. Mezentsev treated 37 patients with renal stones sized between 6 and 20 mm in patients with BMI more than 40 kg/m^2. A mobile overtable module was used to position the stone in the focal point or within 3 cm of it on the extended shock pathway. In addition, abdominal compression straps were used in 24 patients to overcome difficulties in positioning. The overall stone-free rate of 73% was achieved and the mean number of treatments per patient was 2.1 [11]. It is evident that a comparison between different kinds of lithotripters is not an easy task, since there are lots of differences in the way they work. We believe that our new approach of managing obese patients on the lithotripsy table can be easily reproduced in almost all the electromagnetic lithotripters. Of course, the future prospective studies comparing multiple lithotripters are needed to further evaluate the ability of our technique to treat obese patients with ESWL.

Interestingly, the main benefit of our technique was the avoidance of frequent collisions of the water cushion with the operating table that appears when the abdominal fat "overflows" and moves toward the cushion when the patient lies in the supine position. When a collision occurs, the session should be paused and recommenced when the patient is repositioned. These intervals result in significant delay and in loss of high-intensity shock waves, since there is a progressive (although faster than the initial) increase of shock-wave intensity when the session restarts. Using the lateral position, the excessive abdominal fat lies away from the generator; a fact that ensures better manipulation of the patient on the operating table, minimizing the collisions and shortening the duration of the lithotripsy session. It is obvious that the shorter duration of the session in the modified lateral position (56 min for the modified and 73 min for the supine position) has a direct positive impact on the normal function of the Healthcare Lithotripsy Unit, since it allows the flow of patients to be kept in line with the scheduled program and more patients to be treated every day. Furthermore, in support of the safety of the new modified treatment position, no serious complication was recorded and no need for hospital admission required.

Study limitations included the rather small number of patients enrolled and the non-randomized design of the trial. One could argue that the difference in the observed success rate and number of sessions could not be considered clinically negligible and could reach statistical significance in a larger cohort of patients. This underlines the need for further studies with a larger number of individuals. In addition, in our study there was not any metabolic workup or stone composition analysis and this could potentially influence the final lithotripsy outcome between the two groups, as it is evident that more dense stones are less susceptible to stone fragmentation.

Conclusions

ESWL in the modified lateral position for renal calculi in obese patients seems to be feasible and safe. In addition, it is faster than in the supine position since it overcomes

technical difficulties. However, additional studies with a large numbers of patients are warranted to confirm these preliminary data.

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