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ORIGINAL ARTICLE

Shock-wave lithotripsy in the elderly: Safety, efficacy and special considerations

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KEYWORDS

Elderly;
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ABBREVIATIONS

SWL, shock-wave lithotripsy; SFR, stone-free rate; PCNL, percutaneous nephrolithotripsy; ASA, American Society of Anesthesiology; ECG, electrocardiography.

Abstract *Purpose:* Shock-wave lithotripsy (SWL) for elderly patients can be challenging. Patients often have a long-standing complex stone burden and significant comorbidities. We report a cohort of patients aged ⩾70 years who were treated by SWL, with special attention to treatment outcomes, complications and the need for adjuvant procedures.

Patients and methods: Over a period of 4 years, 2311 patients were treated with SWL in a tertiary referral centre. Among these patients, 137 were aged ⩾70 years (5.9%). Patient and stone data were obtained from an electronic database and the patients' electronic medical records were reviewed.

Results: During the pre-procedural assessment, 29 patients (21.2%) were considered to be at high anaesthetic risk, due their comorbidities (American Society of Anesthesiology score 3+). In terms of stone burden, 16 stones (11.7%) were located in the distal ureter (mean stone diameter 7.9 mm) and 28 (20.4%) were in the proximal ureter (mean diameter 10.1 mm). In the kidney, 54 stones (39.4%) were in the renal pelvis, upper or mid calyx (mean diameter 10.6 mm), while 39 stones (28.5%) were in the lower calyx (mean diameter 10.1 mm). The median (range) number of SWL sessions per patient was 2.0 (1–3). The overall stone-free rate achieved by SWL alone was 63.5% (65.9% for ureteric stones and 62.4% for renal stones). In total, 38 patients (27.7%) had an adjuvant procedure to achieve stone clearance (ureteroscopy in 23, PCNL in 14 and laparoscopic ureterolithotomy in one case). Apart from six cases (4.3%) of ureteric obstruction due to steinstrasse, there were no severe complications noted.

Conclusions: The management of elderly patients presenting with urolithiasis is challenging, due to the presence of significant comorbidities. Careful assessment of an integrated management plan for geriatric patients with urolithiasis is essential, and SWL still remains a safe and efficient first-line tool in well-selected cases.

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Introduction

Shock-wave lithotripsy (SWL) is currently considered one of the first-line tools for treating urolithiasis. The major technological improvements and expanding experience in the use of the technique have not only added to its safety, but also highlighted its limitations. International expert panels and authorities have issued practical guidelines, to optimise patient selection, maximise stone-free rates (SFRs) and minimise adverse effects. However, these guidelines usually refer to the index patient [1], i.e. a nonpregnant adult, with a unilateral radio-opaque stone, a normal contralateral kidney and whose medical condition, body habitus and anatomy allow any one of the available treatment options to be undertaken. These guidelines do not clarify the role of SWL for managing patients outside these parameters [2], i.e. elderly patients. Longer life-expectancy, the tendency for pro-active management of stone disease, and high recurrence rates will lead to an increase in elderly patients referred for interventional management of upper urinary tract calculi in the future.

We present the experience of a tertiary referral centre in the management of patients aged $\geqslant 70$ years with urolithiasis treated with SWL. In particular, we focus on appropriate patient selection, points of technique, safety issues, complications and efficacy. The special issues of relevance in this population, such as anaesthetic risks, underlying medical conditions, difficulties in positioning due to musculoskeletal deformities, benefit and risk balance, progressive reduction in renal reserve due to age-related glomerulosclerosis, and pain tolerance, contribute to the notion that geriatric patients presenting with stone disease should not be considered a mere extension of the population of younger stone formers and essentially represent a management challenge [3].

Patients and methods

Between September 2005 and August 2009, 2311 patients were treated by SWL in a tertiary referral centre, and their demographic and clinical variables were included in a prospectively created electronic database. From this database, the data on 137 patients (5.9%) aged $\geqslant 70$ years were retrieved and analysed for the purpose of the current study. The patients' demographic variables and clinical characteristics of stone location and size are summarised in Table 1. Patients with complete staghorn calculi, who underwent SWL in combination with percutaneous nephrolithotripsy (PCNL) as part of a planned combined management scheme, as well as patients with unknown follow-up status and those with radiolucent stones, were excluded from the study.

Table 1 Demographic variables and clinical characteristics of 137 patients with stone disease.

Variable	*n* (%)
Male/female	105 (76.6)/32 (23.4)
Mean (range) age, years	76.1 (70–88)
Stone location/mean stone diameter, mm	
Distal ureter and vesico-ureteric junction	16 (11.7)/7.9
Proximal ureter	28 (20.4)/10.1
Pelvis, upper or mid calyx	54 (39.4)/10.6
Lower calyx	39 (28.5)/10.1

The diagnosis of urolithiasis was confirmed by either IVU or noncontrast spiral CT. Pre-procedural insertion of ureteric stents or percutaneous nephrostomies was guided by the presence of appropriate clinical indications. Patients considered as high medical risk (American Society of Anesthesiology, ASA, score 3+), as well as patients receiving oral anticoagulants were admitted before the SWL sessions, to achieve adequate preoperative optimization of their cardiovascular status and their clotting parameters. Several patients, who were acutely admitted due to renal colic, received SWL treatment during the same admission.

All patients were treated on a Lithostar Multiline® machine (Siemens Erlangen/Germany). The absence of urinary infection was confirmed before the procedure by a negative urine dipstick test. Standard premedication with 100 mg diclofenac rectally was administered 30 min before the SWL session. Patients with renal and proximal ureteric stones were placed supine, while prone positioning was necessary for distal ureteric stones. The SWL protocol included administration of shock waves under fluoroscopic guidance at a rate of 90 shocks/min. The first 100 shocks were administered at an energy level of 0.1, with the intention to administer a total of 5000 shocks up to an energy level 9 for ureteric stones, and 4000 shocks up to an energy level 4 for renal stones, according to the manufacturer's recommendations. Except for those inpatients returning to the ward, patients were observed in the short-stay unit for 4 h and were discharged if clinically stable.

The patients were routinely reviewed 2 weeks after the procedure with a combination of plain abdominal X-ray and renal ultrasonography. If there was no stone fragmentation or clearance, the patients had a second SWL session. The 2-week follow-up and repeat SWL cycle was repeated once more if needed (no more than three SWL sessions were administered per patient). All patients were reviewed at 6 and 12 weeks after the final SWL session with a combination of plain abdominal X-ray and renal ultrasonography. This follow-up protocol was consistently used in the Department during the entire study period.

The patients' electronic medical records were reviewed for associated medical conditions, anaesthetic risk stratification, stone disease characteristics, need for ureteric stenting or nephrostomy insertion before SWL, technical details of the SWL (number of sessions, positioning, monitoring, tolerability), complications, SWL outcome (at 3 months) and need for adjuvant procedures to achieve stone clearance. The success of SWL treatment was defined as no additional intervention and complete stone clearance or presence of residual fragments of <3 mm in diameter on the plain abdominal X-ray film at 3 months.

Results

The mean (range) age of the patients was 76.1 (70–88) years. In all, 44 patients were treated for ureteric stones (32.1%) and 93 for renal stones (67.9%). The patients' demographic characteristics, and the stone variables are summarised in Table 1. In total, 44 patients (32.1%) presented with upper tract dilatation, while in six the initial presentation consisted of a combination of stone-related upper tract obstruction and sepsis. Before

SWL, 40 patients had a ureteric JJ stent inserted and four had a percutaneous nephrostomy inserted. In all, 90 patients (65.7%) were treated as outpatients, while 47 (34.3%) received SWL treatment as inpatients. In particular, 29 patients were electively admitted due to high medical risk (ASA score 3+) or oral anticoagulant treatment (mean duration of hospital stay 2.93 days), while 18 were admitted acutely for renal colic and received SWL during the same admission (mean duration of hospital stay, 3.44 days).

From the patients' previous medical history there was a wide range of comorbidities with clinical relevance to the management of stone disease (Table 2). Pre-procedural electrocardiography (ECG) was mandatory for all patients, in the context of a dedicated preoperative nurse-led clinic. Before planning an integrated management scheme for patients with a history of cardiovascular disease (history of coronary heart disease, decreased exercise tolerance, history of severe valve disease, New York Heart Association score of >1, presence of a pacemaker), a formal cardiology consultation was requested and the risk vs. benefit ratio was carefully assessed. The patients at high medical risk had SWL under continuous ECG and vital-signs monitoring. In addition, five patients (3.6%) with abdominal aortic aneurysms (median diameter 44 mm) were treated with SWL for renal stones with no complication. The 44 patients under aspirin treatment (32.1%) were instructed to discontinue the drug 10 days before SWL. Aspirin was restarted 24 h after completing the SWL session, provided that the patient remained clinically stable. The eight patients receiving warfarin (5.8%) were admitted before the procedure and the oral anticoagulant was replaced by low molecular weight heparin. The International Normalised Ratio (INR) was assessed daily and SWL used once the INR was confirmed to be below the 1.2 threshold (as per local protocol). The patients were monitored after the procedure for at least 24 h and in the presence of clinical indications (persistent flank pain, frank haematuria, decrease in serum haemoglobin level) abdominal ultrasonography was used, to exclude haematoma formation after SWL. If the patients were clinically stable for at least 24 h after SWL, oral anticoagulation was restarted.

In all, 76 patients (55.5%) were recurrent stone-formers. In terms of pre-existing renal anomalies, 18 patients had a history of chronic kidney disease, three were treated for stones in a solitary renal unit, three had a previous history of open urinary tract surgery (one pyeloplasty and two ureteric reimplantations) and 10 had an underlying renal anomaly (three cases of ureteric duplication, four cases with calyceal diverticulae and three cases with medullary sponge kidney). Three patients had significant lower-limb contractures that made lithotomy positioning practically impossible, making SWL the only minimally invasive option available. The median (range) number of SWL sessions per patient was 2.0 (1–3). Twenty-three patients did not tolerate SWL according to the standard outpatient protocol described above, and required a reduction of either energy level or total shock wave numbers.

Table 2 Underlying diseases and conditions with clinical relevance for the management of stone disease.

Underlying condition	*n* (%) of patients
Hypertension	44 (32.1)
Diabetes mellitus	29 (21.1)
Coronary heart disease	35 (25.5)
History of malignancy	11 (8)
Aspirin treatment	44 (32.1)
Oral anticoagulant treatment	8 (5.8)
Chronic kidney disease	18 (13.1)
Abdominal aortic aneurysm	5 (3.6)
Cardiac pacemaker	3 (2.2)
Inflammatory bowel disease	5 (3.6)

Table 3 SFRs and adjuvant procedures.

Variable	*n*/*N* (%) of patients
Overall SFR (achieved by SWL alone)	87/137 (63.5)
Distal ureter and vesico-ureteric junction	13/16 (81.2)
Proximal ureter	16/28 (57.1)
Pelvis, upper or mid calyx	35/54 (64.8)
Lower calyx	23/39 (59.0)
Adjuvant procedures, total	38 (27.7)
Ureteroscopy/laser fragmentation	23 (60.5%)
Laparoscopic ureterolithotomy	1 (2.6)
PCNL	14 (36.8)
Declined an adjuvant procedure	2 (1.5)
Poor candidates for adjuvant procedures	10 (7.3)

The overall SFR achieved by SWL alone was 63.5%, while 38 patients had an adjuvant invasive stone procedure to achieve stone clearance. The SFRs according to stone location are outlined in Table 3, with the adjuvant procedures used to achieve complete stone clearance. Ten patients were considered poor candidates for more invasive stone manipulations and a decision to monitor the residual stone burden was taken, after balancing the hypothetical risk vs benefit ratio of an invasive procedure.

There were no severe SWL-related complications (such as clinically significant perinephric haematomas requiring admission or intervention, urosepsis, acute coronary events or arrhythmias) in this cohort. There were six ureteric obstructions after SWL, due to steinstrasse (4.3%). These cases involved patients with a significant stone burden (median diameter of the stone 14.5 mm) and were successfully managed either by ureteroscopy (in four) or by insertion of a nephrostomy tube and analgesia alone (in two).

Discussion

Urolithiasis is mainly considered a disease of middle age and only a few reports focus on the epidemiology of this common entity in the geriatric population. However, elderly stone formers (age >65 years) comprise 9.6–12% of all stone patients [3,4] and usually experience the first symptomatic stone-related episode later in life [3]. Their metabolic profile might also differ from that in younger stone-formers, as higher rates of uric acid stones were reported in this population [3]. All these significant differences support the notion that elderly patients with urolithiasis do not represent merely an extension of the younger stone-forming population [2].

This statement has significant implications in the management of older patients with stone disease. Early reports on the use of SWL in this patient group have considered the method safe and effective [5] and these results have been reproduced in more recent reports [6,7]. However, the issue of the efficacy

of SWL (particularly in terms of SFRs) has not been clarified. The question whether age adversely affects the efficacy of SWL has led to contradictory results. An early report on the outcomes of SWL with the use of the HM-3 lithotripter for renal calculi showed lower SFRs among older patients [8]. Abdel-Khalek et al. [9], in a study that included 2954 patients with renal stones treated by SWL, showed in a multivariate analysis that patient age >40 years was a predictor of SWL failure. These findings were not reproduced by more recent reports for stones in the ureter [10,11]. Age was not included in a preoperative nomogram for predicting stone clearance after SWL [12], as it did not represent an independent predictor for fragmentation on multivariate logistic regression analysis. According to the findings of a large retrospective study, stone clearance for renal stones, but not ureteric stones, was affected by age [13]. The authors of that study proposed a hypothesis that age-related changes in the acoustic impedance of the kidneys due to underlying glomerulosclerosis [14] have an impact on the effectiveness of shock wave transmission for renal stones, but not for ureteric stones. This phenomenon might explain both the increased echogenicity of the kidneys during ultrasonography and the lower SFR for renal stones in older patients.

In the present series, the overall SFR achieved by SWL alone was 63.5%. This finding is limited by the lack of comparison to the efficacy of SWL for younger patients. A similar study by Sighinolfi et al. [6], which is also limited by the lack of comparative data, reported a SFR of 87.1%. The lower SFR in the current cohort can be explained by the large proportion of lower-pole stones (28.5%), of relatively large diameter (mean 10.1 mm) included in the study. Many of these patients do not represent ideal candidates for SWL [15,16]. However, their age and previous medical history act as significant limiting factors, making SWL a worthwhile option, to avoid a potentially more morbid procedure. This rationale might explain why many urologists adopt SWL as the preferred management option for lower-pole stones in daily practice [17]. The low SFR for proximal ureteric stones in our series might also be explained by the relatively large diameter (median 10.1 mm) [11,18,19]. At this stone burden range, ureteroscopy performs better than SWL, but necessitates general anaesthesia [1].

For the subgroup of elderly patients not reaching a stone-free status through SWL, the option to proceed with more invasive procedures can be compromised by the presence of high-risk conditions, as well as difficulties in patient positioning. In our series, 10 patients with residual calculi were designated as ASA score 3+, and were considered poor candidates for more invasive stone manipulation, after taking into consideration the risk vs. benefit ratio.

Other groups suggest routine cardiology consultation in all cases of elderly patients undergoing SWL [6]. In our series, we requested a formal cardiology consultation in the presence of relevant cardiovascular indications (as noted above). Despite the fact that morbid cardiac events are extremely rare during SWL [20], a formal ECG was mandatory for all patients, in the context of a dedicated preoperative nurse-led clinic. Further evaluation (such as echocardiography) was decided on an individual basis, according to the formal cardiology risk assessment. For patients with a complex stone burden that might necessitate more invasive procedures in case of SWL failure, a cardiology consultation should be requested before planning a management scheme that encompasses a combination of methods (SWL and/or endoscopic surgery). Performing SWL under continuous ECG and vital-signs monitoring is a reasonable precaution for high-risk patients. Patients under treatment with aspirin, antiplatelet agents or coumarin anticoagulants should be carefully managed, according to local guidelines, to avoid severe SWL-related bleeding events [21]. Abdominal aortic aneurysm has been proposed as a contraindication for SWL, as it has been linked in the past with aneurysmal ruptures [22]. However, patients with abdominal aortic aneurysms have been treated with SWL without complications [23]. According to our experience with five cases, patients with aneurysms can be safely treated with SWL, especially when the aneurysm is not along the pathway of the shock waves. A consultation with a vascular surgeon before proceeding with SWL in this setting is advisable.

In terms of pain tolerance, younger age [24,25] and thin body habitus [24] have been associated with less pain tolerance according to previous reports. In our cohort, only 23 patients failed to reach the protocol target and required a decrease in either energy levels or total shock wave number, thus supporting the notion that older patients experience less SWL-related discomfort.

SWL-related morbidity in the elderly is not well reported in previous literature. However, age is considered an independent predictor of subcapsular or perinephric haematoma formation after electromagnetic SWL [26]. In our series, no clinically significant subcapsular or perirenal haematomas requiring admission or intervention were noted, despite the patients' age and the high percentage of patients with hypertension (32.1%), which is also considered to be a risk factor according to earlier reports [27]. Symptomatic intrarenal, subcapsular or perirenal haematomas are rare and occur in $<1\%$ of patients who undergo SWL [26–28]. However, this rate increases to 20–25% when CT or MRI imaging is used routinely after each SWL session [26]. There is currently an increasing body of evidence that supports age as an independent risk factor for major bleeding in patients receiving oral anticoagulants [29]. Hutten et al. [29], in a systematic review, identified a clear tendency toward a doubling in bleeding events among elderly patients receiving warfarin therapy. The mechanism of how ageing causes anticoagulant-related bleeding in not known and the risk for SWL-related bleeding in older patients receiving oral anticoagulants has not been addressed specifically in the context of a study. Until sufficient evidence is available, elderly patients receiving medication affecting the coagulation cascade should be considered to be at high-risk of haemorrhagic complications due to SWL. Continuous ultrasonographic monitoring during SWL might add to the prompt recognition of these complications and the immediate termination of the SWL session [6].

In conclusion, despite the current trend for proactive management of stone disease, the pathophysiological changes affecting the elderly should be carefully evaluated before planning any invasive procedure in such patients [30]. Careful assessment of an integrated management plan for geriatric patients with urolithiasis is essential and SWL is still considered a first-line tool for these cases. Appropriate patient selection is of utmost importance, to achieve a high stone-clearance rate by SWL, but the presence of significant stone burden in the elderly might explain the need for multiple SWL sessions and adjuvant procedures.

Disclosure statement

The authors have no competing financial interest to disclose.

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