In Clinical Practice

Rolf Schmutz · Frédéric Birkhäuser
Pascal Zehnder

Extracorporeal Shock Wave Lithotripsy

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Developing a thorough and individual procedural strategy—not only for each patient, but for each stone—is the major prerequisite for successful SWL.

(Rolf Schmutz, 2017)

Preamble 1

The introduction of SWL in 1980 was a real game changer in the management of urolithiasis. Open stone surgery became obsolete with very few exceptions. There never was a randomized clinical phase 3 trial comparing open surgery versus SWL to evaluate the effectiveness. For many years the Dornier HM3 was the standard; the last “bathtubs” have become museum pieces not so long ago. Newer generations of lithotripters followed.

Over time other technical developments have led to minimally invasive approaches to remove stones competing with SWL. The use of these novel approaches was further supported by more and more aggressive platelet anti-aggregation drugs and decreasing reimbursement for SWL. The era of SWL seemed to falter.

Nevertheless, SWL continues to be part of the armamentarium in the modern management of urinary stone disease, and after competition with more and more sophisticated endoscopic treatment forms has been recognized as an important complement in the management of patients with urinary stone disease in big centres of excellence rather than a competing method.

But through waning interest in SWL much of the know-how has been lost; as in many centres often the youngest resident was obliged to treat patients on the lithotripter while the more experienced residents performed the “more elegant” and “interesting” minimally invasive endoscopic operations. As to be expected, results were less and less satisfactory, confirming the critics.

Know-how and experience are crucial for any treatment, be it SWL or endoscopic. Few people have treated so many stones as has Rolf Schmutz. Few people have treated stones with such enthusiastic energy and achieved good results. Meticulous planning of the treatment, experience in localizing and focusing the stone, recognizing the "true nature" of the stone and integrating all these factors are the basis of successful SWL.

Rolf Schmutz introduced generations of young urologists to these secrets of successful SWL stone treatment. His commitment and unaltered enthusiasm were exemplary. The two editors of this SWL manual, Dr. Birkhäuser and Dr. Zehnder, are to be complimented for motivating Rolf Schmutz to put down in writing and in figures the know-how of a lifetime with SWL for future generations.

Like a good cookbook should be, the processes of SWL are well described, practical and pragmatic, and the figures easy to read to make any reader willing to commit himself an outstanding SWL chef.

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Preamble 2

SWL is internationally acknowledged as one of the most remarkable innovations in medicine within the last 50 years. Its success was supported by the motivation and engagement of the first teams who integrated these new technologies in their clinical practice.

One of these pioneering centres was the Department of Urology in Bern, Switzerland, with Prof. Ernst J. Zingg as chairman. He and his team established very sophisticated regulations for the use of SWL and its indications, which led to the distribution and acceptance in Switzerland. A man of the first hours was Rolf Schmutz, author of this booklet, who has performed treatments on nearly 20,000 patients. All of them with excellent results.

Unfortunately, the quality of treatments differs and the results vary considerably from one centre to the other and from one operator to another. As a consequence of occasionally poor treatment results, it can be noticed that the popularity of SWL has decreased during the past decade. This development can—to a large extent—be explained by the technical development of instruments for endoscopic procedures and the increased skill in the application of these techniques in combination with the mostly higher reimbursement for more invasive treatments. However, this development is also a result of insufficient attention to the basic principles of how SWL should best be carried out.

With proper equipment, the understanding of the basic physics of shock waves and adequate training of the operators in the safe application of shock wave energy, results are excellent and complications are minimal. In order to achieve optimal treatment results with SWL, an understanding of the technique and the knowledge of necessary treatment protocols are essential. The authors provide with this excellent and very informative booklet practical guidance on how to perform SWL best.

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We are particularly grateful to our partner Dr. med. Felix Moltzahn who enabled us to finalize this project with his tremendous contributions. With his expertise and dedication, he helped to translate Rolf Schmutz's specific clinical knowledge in a worldwide applicable form and to support it by current scientific evidence. From a clinical perspective, he is in charge to preserve and spread the intellectual heritage of successful shock wave lithotripsy as a truly minimally invasive therapy.

Our sincere thanks also go to Neeser & Müller, Visuelle Gestaltung (Basel, Switzerland), with Mr. Rolf Joray for the creation of the graphic figures and the layout concept, which both contribute tremendously to the comprehensive understanding of this book. We also address our special thanks to the Max und Hedwig Niedermaier foundation (Zurich, Switzerland), which supported this project financially.

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Portrait of the Author

Rolf Schmutz has been one of the pioneers in using SWL in Switzerland. Over a period of 30 years in his profession, he treated more than 60,000 stones in 26,000 patients.

During his professional time, he worked with different lithotripter models, starting with the HM3 and Sonolith Wolf, Lithostar Ultra, Storz Generation 1 as well as with the EDAP Sonolith i-sys and the Storz MODULITH SLX-F2.

Rolf Schmutz has always been focused on optimal patient treatment and on the training of colleagues. In his free-time he is a passionate diver and well-known diving instructor in Switzerland.

Introduction

The purpose of this book is to compile and to share an individual lifelong professional expertise and practical advice in a simple and comprehensible manner in order to support optimal extracorporeal shock wave lithotripsy (SWL).

This book is based on both scientific evidence and personal observations and intends to serve as a practical guide. It aims at providing its readers with background knowledge and at contributing to successful SWL by offering pragmatic guidance. Making a series of correct individual decisions—as shown below—is the prerequisite for successful treatment.

The book is divided into three chapters. Chapter 1 contains fundamental principles and provides helpful tricks and tips for the implementation in an optimal treatment. Chapter 2 gives practical advices on how to perform SWL in a structured manner, not only in daily routine but also in special and demanding situations. Chapter 3 provides treatment examples and illustrates the above discussed stone situations by elaborating individual strategy, therapeutic procedure, and outcome. Hopefully, you will enjoy the reading and thereby improve your SWL treatment skills.

Please be aware that all given specifications in this book (e.g. shock wave frequencies, energy levels) result from personal experience of the author and are specific for Storz® lithotripter. In case of SWL treatment using different lithotripters, please contact the manufacturer for equivalent treatment parameters, which will allow you to translate the instructions given in this book. It is strongly recommended to adhere to manufacturers' specifications.

Chapter 1
Principles of SWL

History of SWL

The development of SWL started in the 1960s based on an accidental discovery by Claude Dornier. He observed that the wings of an airplane flying at the speed of sound could be damaged by raindrops resulting in plane crashes. It was shown that the damage was not only caused externally by pure impact; considerable damage was particularly observed within the material. This was caused by resulting shock waves, which were transferred inwardly by the water.

This insight was the basis for the idea of treating kidney stones with the help of targeted shock waves in humans. A collaboration of technicians, urologists of the hospital of the Ludwig-Maximilians-University in Munich, Germany, and industrial companies led to the development of the first standard lithotripter "Human Model 3" (HM3) in 1980.

The clinical use of SWL rapidly spread, and this truly non-invasive procedure evolved into the preferred alternative compared to open stone surgery, which became obsolete. The high level of initial effort and the high cost in particular (nowadays approximately two million Euros) resulted in permanent technological advancement. For example, the famous "bathtub" of the HM3 was replaced by a water-coupling cushion.

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While SWL experienced a loss of importance due to the simultaneous advancement of endourological techniques, it still continues to be of significance for many indications [1].

Fundamentals

Shock waves are acoustic impulses of high energy. They are produced outside the body (extracorporeal) and at various levels of energy by using different (electro-hydraulic, electromagnetic, piezo-electric) techniques (Fig. 1.1). Within the body, the shock waves are transmitted unaffected through aqueous tissues, and the intended region of treatment can be focused.

When hitting solid boundary, a variety of forces is created, such as highly energetic positive pressure peaks (tear/shear forces), negative tensile forces, and phenomena like spallation, quasi-static squeezing and cavitation (implosion of cavities), which eventually lead to the fragmentation of the targeted stones [2].

Figure 1.1 Urological multifunctional table with SWL generator. (*1*) Operating unit, (*2*) X-ray, (*3*) Examination table, (*4*) Shock wave generator

Criteria for Outcome Optimisation

Anaesthesia and Analgesia Management

In principle, SWL can be performed in patients under either anaesthesia (spinal, peridural or tracheal intubation) or analgesia. Successful treatment is generally based on shock waves hitting the desired target. Pain will lead to patient movements, which may result in shock waves hitting surrounding tissue rather than the stone. Anaesthesia reduces this problem and, furthermore, permits the application of highest energy levels if necessary. Pain also leads to increased breathing movements, which may again decrease the precision and efficacy of each individual shock wave.

Though analgesic treatment may help to reduce such problems, it is not nearly possible to use comparable maximum energy levels as it is in patients under anaesthesia. In addition, X-ray settings must be controlled more often and/or reset completely in cases of extended treatment duration and in patients with declining analgesic efficacy, which may increase fluoroscopy and total treatment times. Moreover, the location of the stone and the scheduled treatment duration also are important variables of decision-making.

Benefits of treatment under anaesthesia	**Benefits of treatment under analgesia**
Less patient movements ⇒ More shock waves in target	No anaesthetic risks
More consistent breathing movements ⇒ More shock waves in target	
Higher maximum energy levels	
Entire therapy in one session	
Possibly: shorter fluoroscopy times	
Possibly: shorter treatment duration	

The preferred objective is to pursue complete lithotripsy under optimal conditions (comfortable, quiet patient and maximum energy levels as needed) possibly within **one** treatment session. This objective can be supported by keeping the patients relaxed (e.g. with background music or headphones) and painless for the entire duration of treatment. The alternative treatment in analgesia and potentially suboptimal lithotripsy may imply a higher risk of more than one treatment.

Patient Selection

In addition to SWL, other surgical procedures for stone treatment are available, e.g. Ureterorenoscopy (URS) and Percutaneous Nephrolithotomy (PCNL). Each technique has its justification in different stone situations. Guidelines provide general assistance when selecting a suitable procedure. Differences may be based on local (e.g. available equipment) and personal conditions (e.g. preferences, expertise) [3].

Other than with URS and PCNL, the objective with SWL is complete disintegration of the stone, however not its removal. Note: Location, size, and mineral composition (hardness) are the most important predictors of SWL success.

Degrees of hardness in decreasing sequence: Brushite (calcium hydrogen phosphate), cystine, calcium oxalate monohydrate, struvite, calcium oxalate dihydrate, uric acid. However, stone composition is commonly not known prior to therapy.

X-Ray Settings for Stone Targeting

Locating the Stone in Different Axes

Table mobility is classified in x-, y-, and z-axis. Movement towards head and feet is defined as x-axis while lateral movement towards right and left is defined as y-axis (Fig. 1.2).

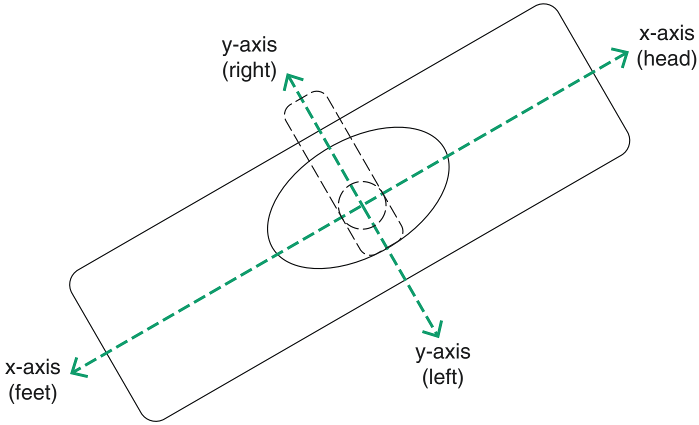

FIGURE 1.2 Defining x- and y-axis

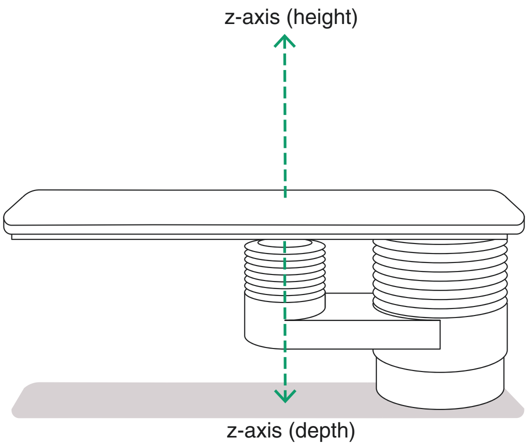

FIGURE 1.3 Defining z-axis

Vertical table movement is defined as z-axis (Fig. 1.3).

Prerequisite for a successful treatment is the safe and correct stone localization in both, the 0° and 30° camera position (Fig. 1.4).

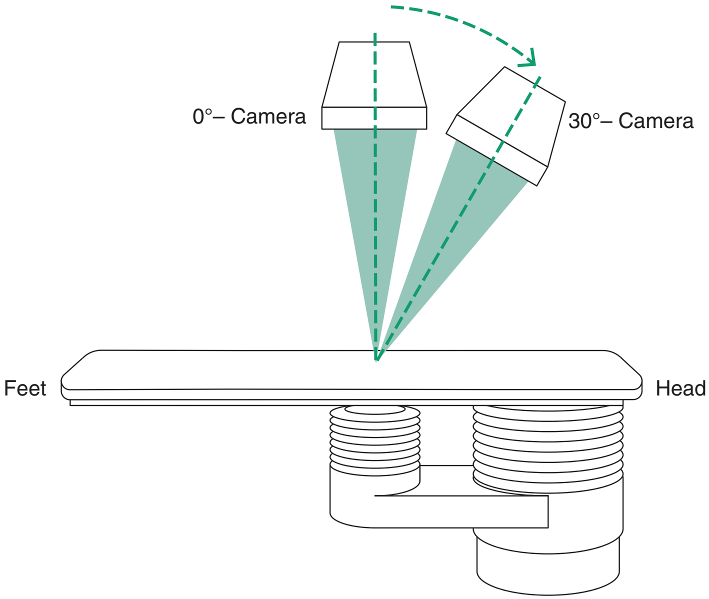

FIGURE 1.4 Camera position in 0° and 30°

The localization approach starts within the 0° projection. The goal is to position the stone in the centre of the focus by adjusting all three dimensions x-axis (left-right), y-axis (head-feet) and z-axis (height-depth). Using fluoroscopy, the stone is first brought into position in the x-axis (arrow 1), in this example by moving the table into feet direction. This is followed by correction of the y-axis (left-right, arrow 2). To finally position the stone in the z-axis (height-depth, arrow 3) adjustment is made in the 30° projection and the stone is then centred into the treatment focus, in this example by raising the table level (Fig. 1.5).

Safe and precise stone localization in the 0°–30° plane is a basic requirement for successful SWL. Be aware of the different geometric views in the different projections (Fig. 1.6).

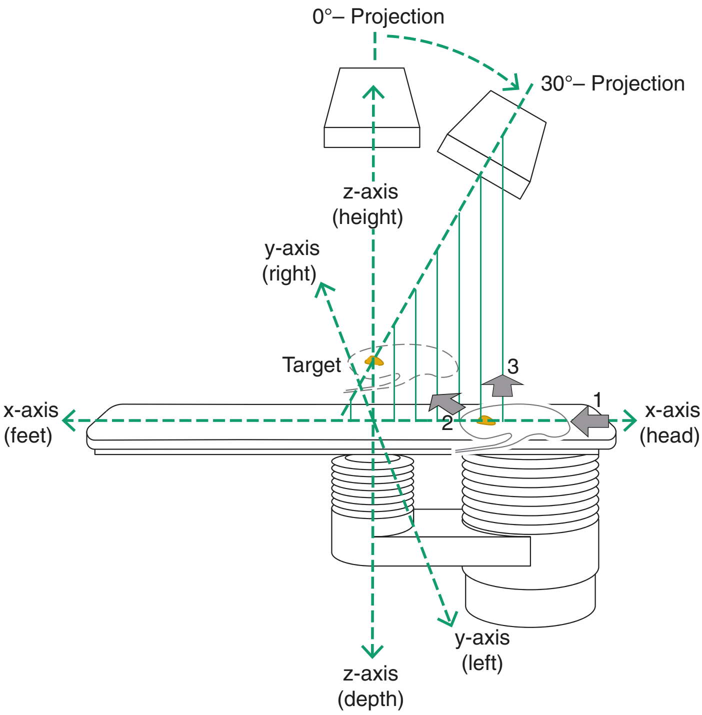

FIGURE 1.5 Positioning of the stone into the focus

Factors such as high body mass index, pronounced medial or lateral stone positions, partial overlapping by bony structures, or complicating factors such as phleboliths, overlapping by intestinal gas, or anatomical anomalies may complicate localization considerably. Therefore, trial detection prior to anaesthesia and therapy can sometimes be useful in order to prepare suitable corrective measures in advance.

Possible measures for the optimization of stone detection in the 30° plane are: compression belts and wedges, lifting or lowering of the table membrane, and lifting or lowering of the coupling cushion.

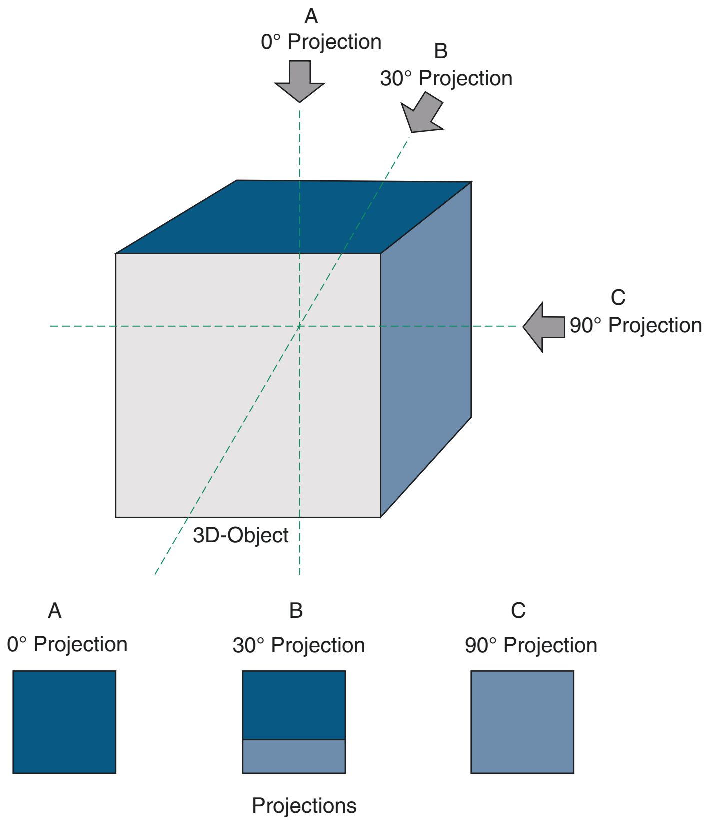

FIGURE 1.6 Visualisation of a 3D object in 0°, 30° and 90° projection, shown as it would be displayed on a radiologic screen

X-Ray Collimation

Based on the ALARA principle (AsLowAsReasonably-Achievable), it is attempted to reduce radiation to a minimum [4]. Therefore, in patients with ureteral stones the use of the narrowest X-ray collimation is recommended. In patients with kidney stones, a survey radiograph mode is used to follow stone fragmentation during the treatment in order to keep track of the procedure, and to be able to respond to possible fragment dislocation.

Equipment Settings

Coupling

It is important to establish a bubble-free and permanent coupling between the shock wave generator and the patient's body. Even small bubbles of air increase impedance and lead to the significant reduction of shock wave energy levels. Therefore, check repetitively for a bubble free environment before and after major patient movements. Coupling is warranted using oil on the generator that is attached to the table membrane. The patient is positioned on top of the table membrane and warm water is added to optimize the contact between generator and patient. Again, be aware of a bubble free environment. Oil should only be applied shortly before swivelling-in the generator; otherwise it may be drained at the edge of the generator. When using ultrasound gel, it must also be freed from air bubbles, because this leads to a decrease in treatment efficiency by up to 25% [5].

Focus Size

Focus size is important for successful SWL. Due to the low risk of migration at the beginning of the treatment, ureteral stones will be treated with a small shock wave focus and, thus, higher energy levels. Kidney stones tend to show increased mobility, and shock waves may lead to a change of position within the calyx system. Therefore, a larger focus is recommended. Be aware that not all lithotripter may have the option to change focus size.

Ramping

Treatment starts at lower energy levels, followed by progressive augmentation (ramping), rather than applying maximum energy levels right at the beginning. Available evidence on potential positive effects is ambiguous. Based on clinical experience and on studies ramping is recommended, because it is likely to cause a type of renal adaption with initial vasoconstriction. Vasoconstriction leads to an increase in vessel stiffness and decrease in local blood flow [6]. While treatment outcomes seem to be similar with or without ramping, it is beneficial in terms of perirenal hematomas [7]. Other studies have shown the same effect but postulate that it is caused by the short recovery breaks for the kidney when switching levels rather than by the incremental increase of energy [8].

Frequency

Clinical experience suggesting that shock waves applied at a frequency of 90 Hz lead to better fragmentation and less tissue damage compared to 120 Hz was confirmed in a clinical study [9].

Level of Energy

The level of shock wave energy applied is not static. At the beginning of the treatment, it is set in accordance with stone localization and urinary tract anatomy. Over the course of the treatment, it is adapted depending on the results of fragmentation. Particularly in the kidney, high levels of energy may disseminate stone material into other calyces, and one could easily lose track of the treatment. If the level of energy at the stone is set too low or too high, the results of the lithotripsy procedure may not be satisfactory. In this book, all specifications, particularly treatment parameters are based on clinical experience with Storz equipment. In case of uncertainty one should contact the lithotripter company (see introduction).

Amount of Shock Waves

The maximum amount of shock waves depends on the type of equipment, on energy levels, and on stone localization; there is no generally valid recommendation. All specifications in this book are based on clinical experience of the author with Storz equipment. In case of uncertainty one should contact the lithotripter company (see introduction).

Patient Positioning

As a standard, SWL is performed in supine position (Fig. 1.7a). Treatment in prone position (Fig. 1.7b) is chosen, when stones cannot be reached by shock waves directly in supine position, e.g. in cases with overlapping bony structures. Published results suggest no significant difference of stonefree rates comparing treatment in supine or prone proposition. However, treatment in prone position is considerably more demanding than treatment in supine position.

The precise visualization of the stone and the free access of the shock waves must be ensured for good disintegration results. If this is not possible with initial stone position, there is also the possibility of stone repositioning (see below).

As a basic principle treatment in supine position can be recommended only for cases, where 100% of the stone(s) lie(s) outside the bony structure or when it is possible to relocate the stone in such a position. Consider trial detections in awake patients in different positions and with application of different supportive manoeuvres.

Stone (Re-) Positioning

Generally, stones with partial or complete overlapping by bony structures represent a particular challenge. Such cases require treatment concepts that must be developed prior to therapy initiation, including special positioning techniques (e.g. prone position, using wedges, compression belts) adjustment of equipment parameters (e.g. surface pressure of the

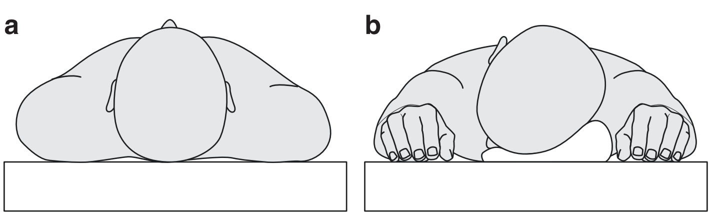

Figure 1.7 (**a**) Supine position. (**b**) Prone position

energy membrane) and/or manipulations with stone position adjustments (e.g. push, placement of ureteral catheter).

The stone should be freely accessible by the shock waves in order to ensure optimal disintegration. Therefore, bony structures in the vicinity of the stone are problematic. Hereafter, potential "stone relocation" manoeuvres will be described; they may be tested prior to anaesthesia induction in a trial detection.

- Stone (re)location per positioning procedures:
  - *Prone position:*

    Due to the body weight on the one hand and the surface pressure of the energy source on the other hand, the geometric precision of the stone *per se* will be slightly modified.

  - *Wedge-shaped cushions:*

    In patients with ureteral stones overlapping with bony structures, one can try to optimise stone position by using wedge-shaped cushions placed underneath the opposite side of the pelvis in order to allow for treatment in supine position (Fig. 1.8). If stone position is still overlapping with bony structures despite using wedges and cushion pressure, treatment must be conducted in prone position.

  - *Compression belts:*

    If the stone is in the z-axis outside the shock wave focus, one may try to move the stone position closer to the focus by using compression belts or elastic bandages.

- Stone mobilisation by adjusting equipment parameters:
  - *Lifting the energy membrane:*

    Lifting the energy membrane is rarely performed, and mainly used to establish coupling in children.

- Stone mobilisation by stone manipulation:
  - *Push in patients with ureteral stones:*

    Via cystoscopy and insertion of a ureteral catheter (UC) with central opening underneath the stone and injec-

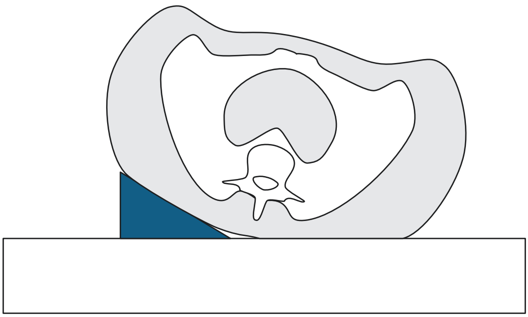

FIGURE 1.8 Wedge-shaped cushion placed underneath the opposite side of the pelvis

tion of an isotonic sodium chloride solution/glycine mixture (60%:40%). This can help to cranialize the stone out of the overlapping bony area into the treatment window.

Caution must be exercised particularly in patients with dilated renal pelvis due to the risk of increased pressures within the calyx and resulting forniceal rupture.

Moreover, perioperative antibiotic treatment should be administered with this kind of manipulations because of the risk of submerging bacteria.

Do not use contrast media, since it would make subsequent stone assessment impossible.

– *Temporary UC insertion:*

After mobilisation out of the overlapping bony area by applying a push, the UC should be left *in situ* underneath the stone in order to prevent a new stone dislocation.

If the push cannot be performed, do not force it. Either switch modality (e.g. URS) or switch into prone position following UC positioning underneath the stone.

Ensure proper fixation of the UC to a urinary catheter (e.g. by knots or bonding) in order to prevent dislocation during change of patient positioning.

Treatment in prone position may be challenging, since stone detection is complicated by overlapping bony structures. Preceding UC positioning underneath the stone may be very useful for this.

Treatment Planning

Treatment Initiation at the Stone

The treatment of the stone *per se* always starts at the location of the largest boundary layer between stone and urine. The entry of urine into the stone increases its boundary layer and the efficacy of the shock wave energy. In case of a wide calyx neck beginning at the surface opposite from the renal papilla allows sand to discharge through the calyx neck, while the fragment is kept in the calyx.

In contrast, this does not apply to stones, which are located in a calyx with narrow calyx neck. In such cases, focussing at treatment initiation is directed to the centre of the stone. Equipment parameters need to be adjusted (see respective treatment chapters) and higher energy levels are used right from the beginning. Once the stone disintegrates and its volume approximates the calyx system, one may continue with lower energy levels. See individual chapters for more information on each treatment strategy.

Treatment Sequence in Patients with Multiple Stones

Appropriate visualisation is a basic requirement to allow for fragmentation assessment. In cases of inappropriate treatment sequence, fragments may, for example, fall into subjacent calyx systems and partially cover local stones, which would complicate their treatment and the assessment of fragmentation progress. Similarly, it does not make sense to treat renal stones, if a ureteral stone is at the same time blocking the urine drainage.

Illustrations in the respective chapters will demonstrate and substantiate treatment sequence.

Pharmacotherapy

Antibiotics

Prior to stone treatment, patient should be free of infection as confirmed by urinalysis. Peri-interventional antibiotic therapy is only conducted in patients with known aetiology of infectious stones, or when foreign materials have been placed in the upper urinary tract.

Medical Expulsive Therapy (MET)

In contrast to untreated stones, evidence for stones post SWL demonstrated the benefit of supporting medication, e.g. alpha-blockers and/or nifedipine, in order to increase stonefree rates and reduce pain episodes [3]. Based on clinical experience, the use of tamsulosin and diclofenac sodium starting on the first postoperative day following sonographic exclusion of perirenal hematoma is recommended.

Based on clinical experience, although evidence is not clear, the author favours the intraoperative administration of furosemide in order to increase diuresis and thus stone passage.

Treatment Sequences

- Day –1/pre-interventional:
  - Evaluation of indication and exclusion of possible contraindications.
  - Urinalysis (exclusion of urinary tract infection).
  - Evaluation of current medication (exclusion of non-steroidal anti-inflammatory drugs, platelet anti-aggregation drugs, anticoagulants).

  - Plain abdominal radiography to ensure stone localization.
  - Treatment planning with outline of anatomy, stone position, calyx situation, treatment initiation at the stone, and treatment sequence in patients with multiple stones.

- Day 0:
  - SWL.
  - Beginning of urine filtering (stone analysis).

- Day +1:
  - Clinical visit (fever, pain, fragment passing for stone analysis).
  - Ultrasound regarding urinary drainage impairment and/or perirenal hematoma.
  - Plain abdominal radiography in order to assess the current fragment situation (Steinstrasse, missing fragmentation).

- Week +2/Month +3:
  - Follow-up after 2 weeks only in patients with initial urinary drainage impairment for re-evaluation or in patients with indwelling double-J stent for determining subsequent procedure.
  - Follow-up after 3 months in order to evaluate residual fragments and treatment success.
  - Planning of follow-up (if applicable).

Risk Factors Limiting Successful SWL

A variety of known risk factors may limit successful SWL [3]. These include:

- The harder the stone the worse the success of treatment (degrees of hardness in decreasing sequence): Brushite (calcium hydrogen phosphate), cystine, calcium oxalate monohydrate, struvite, calcium oxalate dihydrate, uric acid. Hounsfield units of 1000 or more as confirmed by computed tomography may be detrimental.
- Calyx neck anatomy may impair stone passage. The following findings may be particularly unfavourable: long

lower calyx portion (>1 cm), narrow calyx neck (<5 mm), and steep calyx angles.

- Anatomical specialities in general (e.g. pyelo-ureteral narrowness, horseshoe kidney), osseous deformities (e.g. scoliosis) or foreign matter (e.g. bone cement, endoprosthesis of the hip).
- Massive obesity resulting to large distance to the stone.

Complications Following SWL

- Compared to URS and PCNL, overall complication rates of SWL are lower [3].
- Cutaneous hemorrhage at the area of generator contact is commonly observed, but in most cases not clinically relevant.
- Parenchymal or capsular hematoma of the kidney (Fig. 1.9): rates depend on applied energy values, the amount of applied shock waves, diagnostic modality and patient factors [10]. Detection rates of hematomas using computed tomography are higher (up to 19%) compared to ultrasound (approx. 1–3%). CAVE: certain parameters increase the risk for hematomas (e.g. small focus, bilateral therapy, obesity and cachexia, no ramping, anticoagulants etc.).

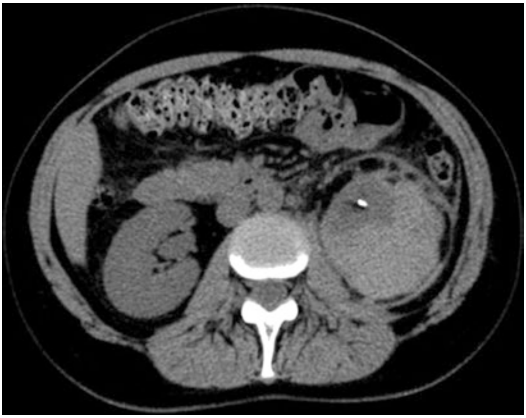

Figure 1.9 Perirenal left-sided hematoma first day after SWL with stone still visible

- Hematuria (common).
- Cardiac arrhythmia.
- Complications of fragment passage with (temporary) ureteral obstruction (from colic to urosepsis).

Clinical experience has shown that nausea and vomiting may occur in individual cases. Please see [3] for other special and more rarely occurring complications such as arterial hypertension, diabetes mellitus, loss of renal function and (ureteral) strictures.

Contraindications for SWL

As with all surgical interventions, there are situations where SWL must not be used [3].

- Florid urinary tract infection → risk of urosepsis.
- Impaired drainage distal to the stone → lack of passage capability, risk of urosepsis.
- Impaired hemostasis → risk of hemorrhage.
- Anticoagulation (including non-steroidal anti-inflammatory drugs, platelet anti-aggregation drugs, anticoagulants) if stone is in projection of the kidney → risk of hemorrhage.
- Uncontrolled hypertension → increases the risk of bruising.
- Renal failure → stone passage not possible.
- Aneurysm in the target region → risk of damage of aneurysm.
- Stones that cannot be located by conventional X-ray, fluoroscopy or ultrasound, e.g. in massive obesity, radiolucent stones without possibility to apply contrast media.
- Pregnancy → potential harm to the foetus.
- Please follow instructions of lithotripter and implant manufacturers in patients with pacemakers or defibrillators.

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Chapter 2
SWL Therapy

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Standard Situations

Solitary Unilateral Kidney Stone Lower Calyx

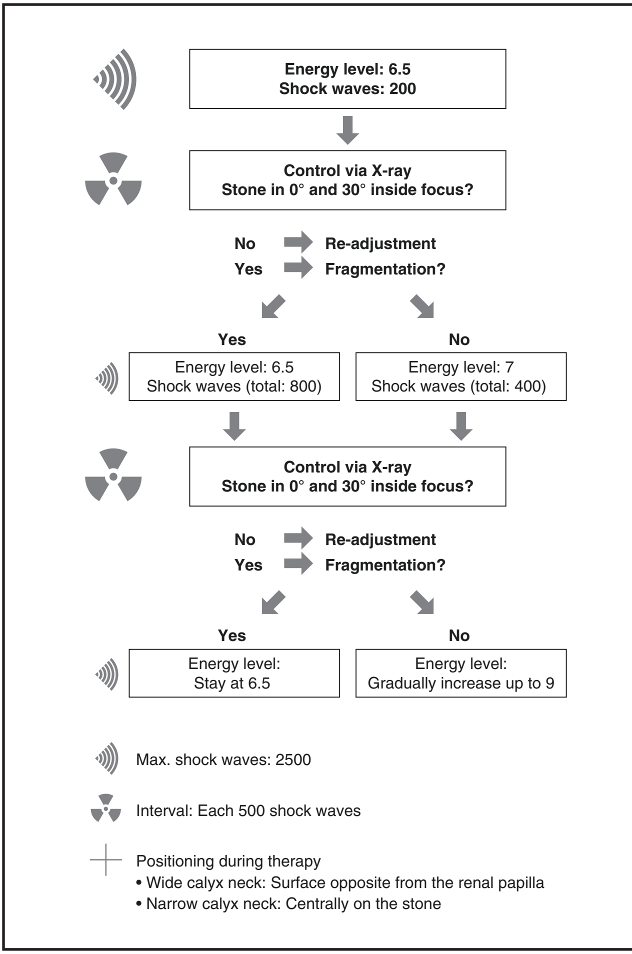
Preparation

Patient position	Supine position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrows Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally on the stone
Energy level at beginning	According to calyx neck anatomy: wide: 6.5, narrow: 7
Shock waves at beginning	200

Therapeutic procedure



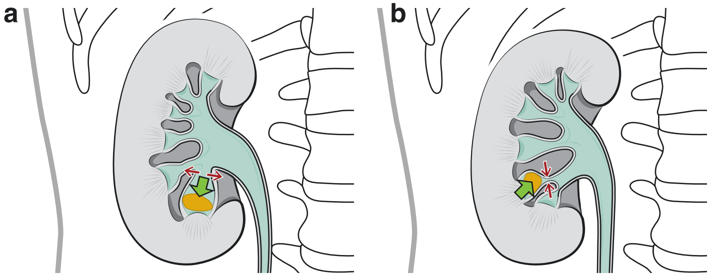


FIGURE 2.1 (**a**) Lower calyceal stone with wide calyx neck (red arrows); (**b**) Lower calyceal stone with narrow calyx neck (red arrows). Note the different starting areas at the stone (green arrows)

Tips & Tricks

- In cases of wide calyceal neck (Fig. 2.1a, red arrows), start treatment at the opposite of the renal papilla (green arrow, largest boundary layer between urine and stone). Fragments may depart in cranial direction, while the stone is retained in the calyx.
- In cases of narrow calyceal neck (Fig. 2.1b, red arrows), start treatment in the centre of the stone (green arrow) and use higher energy levels to begin. The likelihood of achieving central fragmentation is higher compared to fragmentation starting from the edge. In cases of proper fragmentation, energy levels can be reduced in the course.
- Stone migration through the focus should not exceed 1 cm. Excessive breathing movements result in shock waves outside the focus and optimisation is required, e.g. by adjusting respiratory volumes in intubated patients or by pain reduction in patients with analgesia.
- In cases of proper fragmentation, keep X-ray collimation large for overview (monitoring of potential fragment dislocation).
- In cases of insufficient fragmentation or lack of effect: keep X-ray collimation narrow.

- In cases with proper focus positioning on the stone and a lack of visible fragmentation, energy levels must be increased. Monitor for cutaneous hematoma → immediate reduction of energy levels.
- In case of proper fragmentation energy levels should not be increased to prevent unnecessary stone and fragment dislocation and perirenal hematoma formation.
- When fragmentation proves to be efficient, therapy may be finalized prior to achieving the maximum amount of 2500 shock waves.

Solitary Unilateral Kidney Stone Mid Calyx/Upper Calyx/Renal Pelvis

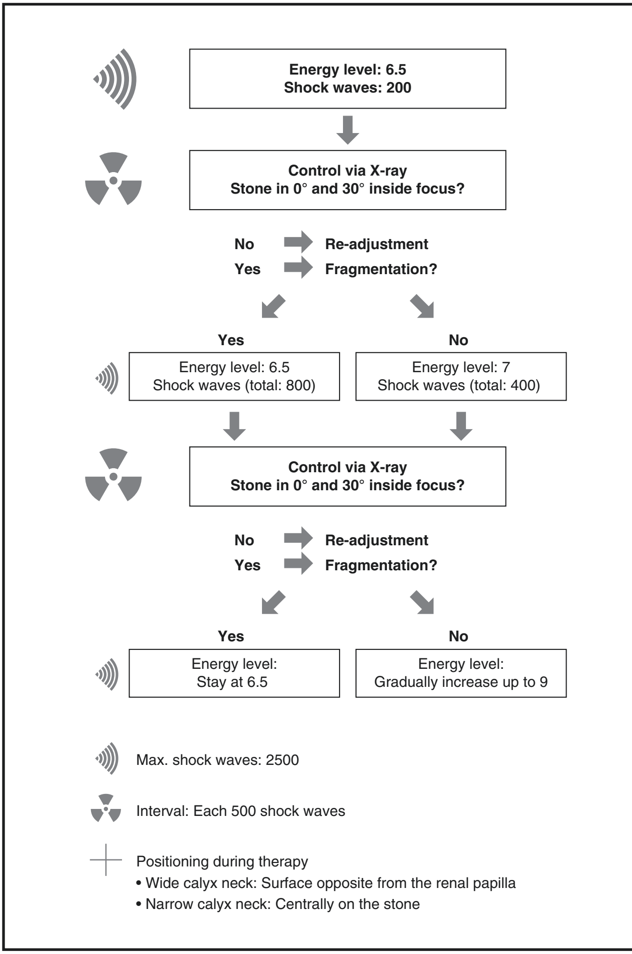
Preparation

Patient position	Supine position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrows Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	According to calyx neck anatomy: wide: 6.5, narrow: 7
Shock waves at beginning	200

Therapeutic procedure



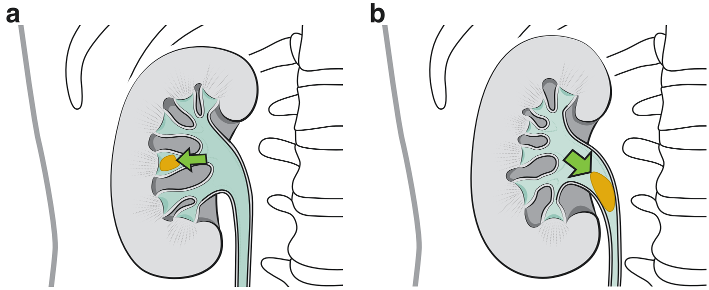


FIGURE 2.2 (**a**) Mid calyx stone, (**b**) Renal pelvis stone. Note the different starting areas at the stone (green arrows)

Tips & Tricks

- In cases of wide calyceal neck (Fig. 2.1a, red arrows), start treatment at the opposite of the renal papilla (green arrow, largest boundary layer between urine and stone). Fragments may depart, while the stone is retained in the calyx. In cases of renal pelvis stones start at the surface towards the renal papillae in order to allow fragments to discharge and to prevent stone dislocation into the pyelon.
- In cases of narrow calyceal neck (Fig. 2.1b, red arrows), start treatment in the centre of the stone with higher energy levels. The likelihood of achieving central fragmentation is higher compared to fragmentation starting from the edge. In cases of proper fragmentation, energy levels can be reduced in the further course.
- Stone migration through the focus should not exceed 1 cm. Excessive breathing movements result in shock waves outside the focus and optimisation is required, e.g. by adjusting respiratory volumes in intubated patients or by pain reduction in patients with analgesia.
- In cases of proper fragmentation, keep X-ray collimation large for overview (monitoring of potential fragment dislocation).

- In cases of insufficient fragmentation or lack of effect: keep X-ray collimation narrow.
- In cases with proper focus positioning on the stone and a lack of visible fragmentation, energy levels must be increased. Monitor for cutaneous hematoma → immediate reduction of energy levels.
- In case of proper fragmentation energy levels should not be increased to prevent unnecessary stone or fragment dislocation.
- When fragmentation proves to be efficient, therapy may be finalized prior to achieving the maximum amount of 2500 shock waves.

Solitary Bilateral Kidney Stones

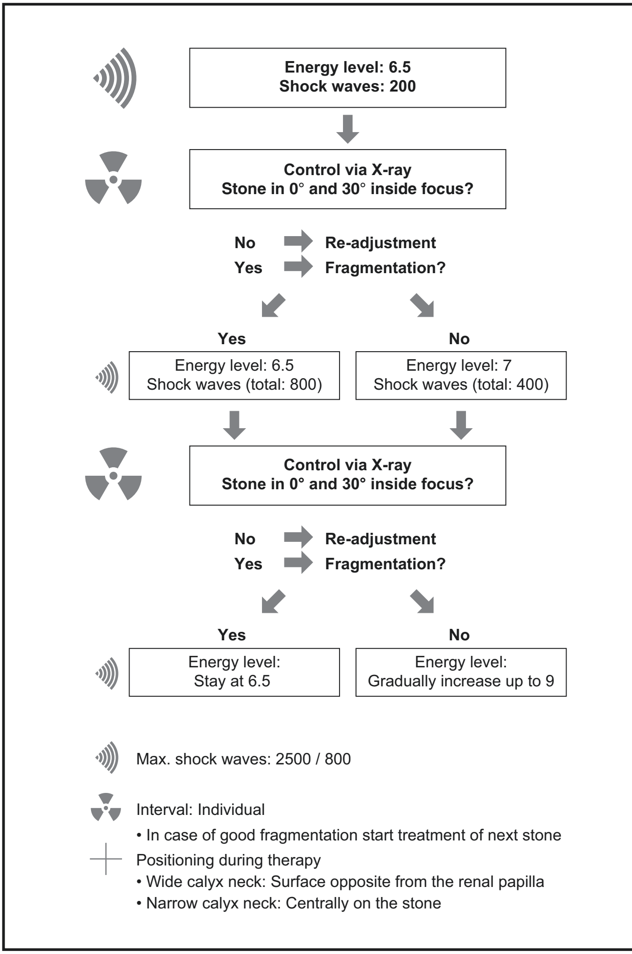
Preparation

Patient position	Supine position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrow Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



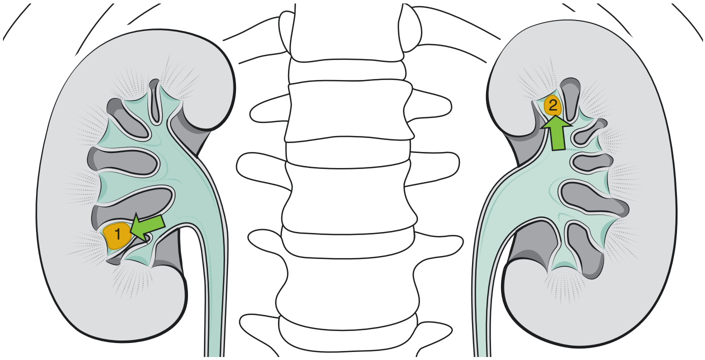


FIGURE 2.3 Solitary bilateral kidney stones. Note the treatment sequence and starting areas at the stone (green arrows)

Tips & Tricks

- A careful planning is prerequisite for a successful therapy:
  - Maximum number of shock waves 2500 for the first, 800 for the second kidney.
  - Start with the symptomatic kidney or, if asymptomatic, the kidney with the higher stone burden.
  - When bilateral therapy is required, the stone volume in the kidney with the lower stone burden should not exceed 8–10 mm. Otherwise sufficient fragmentation may not be achieved with the 800 remaining shock waves. In case of a higher stone burden in the second kidney, it is preferable to schedule two SWL sessions.
  - Be aware of exact stone positions and surrounding anatomy (number of calyxes and their relational positions, potential sites of fragment distribution/dislocation, anatomy of calyx neck) → create a schematic drawing (see blank schematic drawing Fig. A1, Appendix).

  - Plan Individual cross hair positioning for each stone at treatment initiation based on stone position and surrounding calyx anatomy (see chapter solitary unilateral kidney stones). In cases of renal pelvis stones start at the surface towards the renal papillae in order to allow fragments to depart and to prevent stone dislocation into the ureter.
  - Constant observation and overview of/on the fragmentation status allows for prompt response to changes.
  - Consider trial detection for small stones with low density.

- X-ray collimation during reorientation or check-up: large.
- Focus for kidney stones: large.
- Stone migration within the focus should not exceed 1 cm. Excessive breathing movements result in shock waves outside the focus and optimisation is required, e.g. by adjusting respiratory volumes (intubated patients) or by pain reduction (patients with peridural/local anaesthesia).
- In cases with proper fragmentation, maintain energy level.
- In cases with proper focus positioning on the stone and a lack of visible fragmentation energy levels must be increased. Monitor for cutaneous hematoma → immediate reduction of energy levels.

Multiple Unilateral Kidney Stones

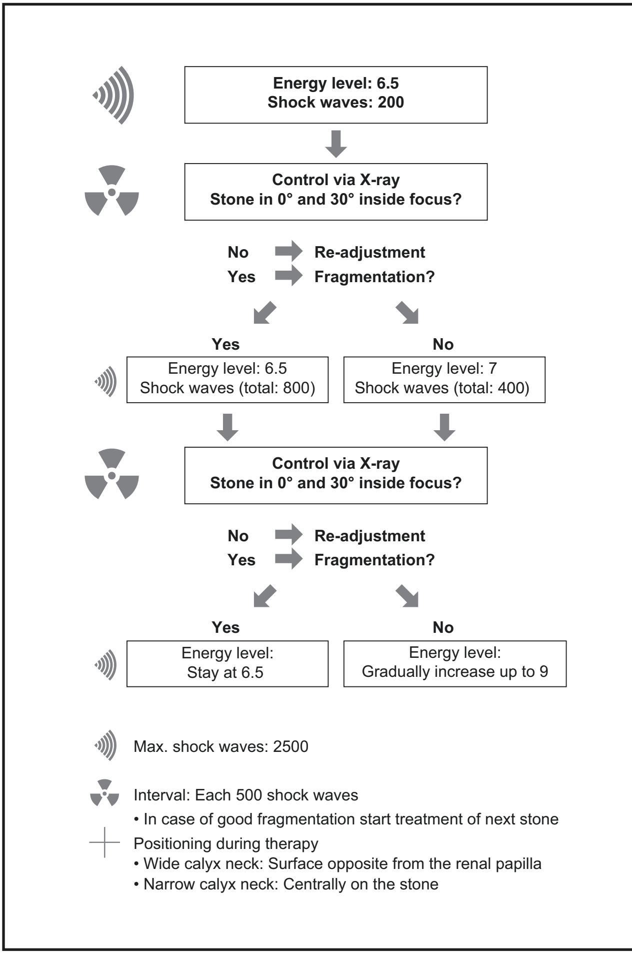
Preparation

Patient position	Supine position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrow Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



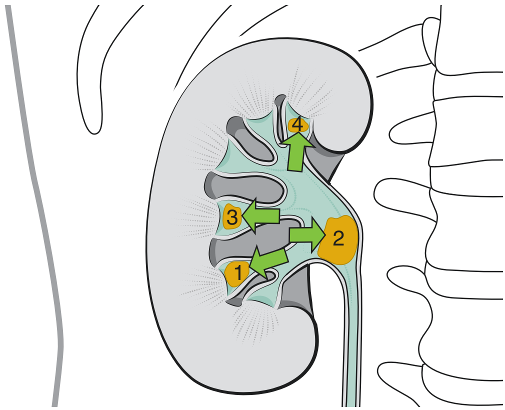


FIGURE 2.4 Multiple unilateral kidney stones. Note the treatment sequence and different starting areas at the stone (green arrows)

Tips & Tricks

- A careful planning is prerequisite for a successful therapy:
  - Be aware of exact stone positions and surrounding anatomy (number of calyxes and their relational positions, potential sites of fragment distribution/dislocation, anatomy of calyx neck) → create a schematic drawing (see blank schematic drawing Fig. A1, Appendix).
  - Consider the maximum amount of possible shock waves (2500) and prioritise. Rather than performing an insufficient "treatment attempt" of all stones, shock waves should be used for the complete therapy of selected stones, and a second SWL session may be scheduled.
  - Plan treatment sequence. If treatment initiation was directly targeted to the pyelon stone in the abovementioned example, fragments may overlap the stone in the lower calyx. This impairs stone visualisation and results in either insufficient treatment or the "wastage" of shock waves. Therefore, begin with the stone in the

lower calyx, followed by the treatment of the pyelon stone to clear the uretero-pelvic junction and to enable for ureteral fragment passage. Afterwards treat from caudal to cranial in order to be able to observe fragmentation and allow fragments to fall into the lower pole and/or ureter. Do not treat renal stones if simultaneously a ureteral stone is blocking urine drainage.
  - Plan individual cross hair positioning for each stone at treatment initiation based on stone position and surrounding calyx anatomy. In cases of narrow calyceal necks start treatment in the centre of the stone. In cases of wide calyceal necks start treatment at the opposite of the renal papilla (Fig. 2.4, green arrow, largest boundary layer between urine and stone). Fragments may depart in cranial direction, while the stone is retained in the calyx. In cases of renal pelvis stones start at the surface towards the renal papillae in order to allow fragments to depart and to prevent stone dislocation into the ureter.
  - Constant observation and overview of/on the fragmentation status allows for prompt response to changes.
  - Consider trial detection for small stones with low density.

- X-ray collimation during reorientation or check-up: large.
- Focus for kidney stones: large.
- Stone migration within the focus should not exceed 1 cm. Excessive breathing movements result in shock waves outside the focus and optimisation is required, e.g. by adjusting respiratory volumes (intubated patients) or by pain reduction (patients with peridural/local anaesthesia).
- In cases with proper fragmentation, maintain energy level.
- In cases with proper focus positioning on the stone and a lack of visible fragmentation, energy levels must be increased. Monitor for cutaneous hematoma → immediate reduction of energy levels.

Multiple Bilateral Kidney Stones

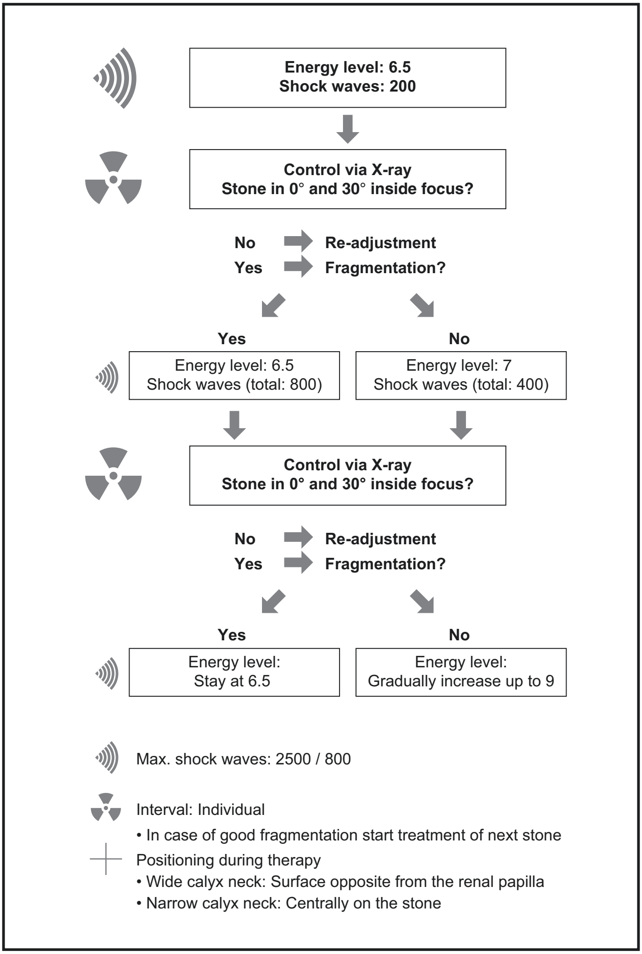
Preparation

Patient position	Supine position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrow Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



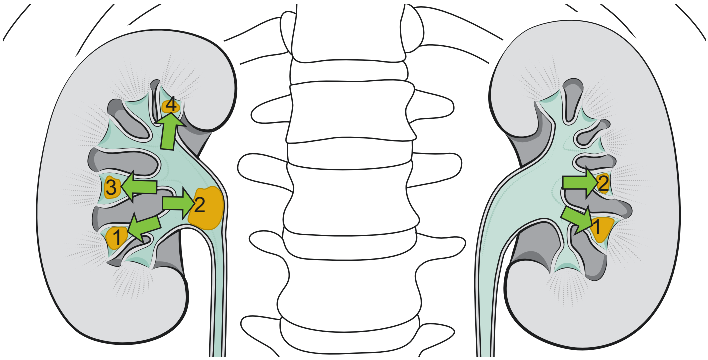


FIGURE 2.5 Multiple bilateral kidney stones. Note the treatment sequence and different starting areas at the stone (green arrows)

Tips & Tricks

- A careful planning is prerequisite for a successful therapy:
  - Maximum number of shock waves 2500 for the kidney with the higher stone burden, 800 for the second kidney.
  - Start with the symptomatic kidney or, if asymptomatic, the kidney with the higher stone burden.
  - When bilateral therapy is required, the stone volume in the kidney with the lower stone burden should not exceed 8–10 mm. Otherwise sufficient fragmentation may not be achieved with the 800 remaining shock waves. In case of a higher stone burden, it is preferable to schedule two SWL sessions.
  - Be aware of exact stone positions and surrounding anatomy (number of calyxes and their relational positions, potential sites of fragment distribution/dislocation, anatomy of calyx neck) → create a schematic drawing (see blank schematic drawing Fig. A1, Appendix).
  - Consider the maximum amount of possible shock waves (2500), and prioritise. Rather than performing an insufficient "treatment attempt" of all stones, shock waves

should be used for the complete therapy of selected stones, and a second SWL session may be scheduled.

- Plan treatment sequence. In cases of inappropriate treatment sequence, fragments may, for example, fall into subjacent calyx systems and partially cover local stones, which would complicate their treatment and the assessment of fragmentation progress. Similarly, it does not make sense to treat renal stones, if a ureteral stone is at the same time blocking the urine drainage. For example, if treatment initiation was directly targeted to the pyelon stone in the above-mentioned example, fragments may overlap the stone in the lower calyx. This impairs stone visualisation and results in either insufficient treatment or the "wastage" of shock waves. Therefore, begin with the stone in the lower calyx, followed by the treatment of the pyelon stone to clear the uretero-pelvic junction and to enable for ureteral fragment passage. Afterwards treat from caudal to cranial in order to be able to observe fragmentation and allow fragments to fall into the lower pole and/or ureter.
- Plan individual cross hair positioning for each stone at treatment initiation based on stone position and surrounding calyx anatomy. In cases of narrow calyceal necks start treatment in the centre of the stone. In cases of wide calyceal necks start treatment at the opposite of the renal papilla (Fig. 2.5, green arrow, largest boundary layer between urine and stone). Fragments may depart in cranial direction, while the stone is retained in the calyx. In cases of renal pelvis stones start at the surface towards the renal papillae in order to allow fragments to depart and to prevent stone dislocation into the ureter.
- Constant observation and overview of/on the fragmentation status allows for prompt response to changes.
- Consider trial detection for small stones with low density.

• X-ray collimation during reorientation or check-up: large.
• Focus for kidney stones: large.

- Stone migration within the focus should not exceed 1 cm. Excessive breathing movements result in shock waves outside the focus and optimisation is required, e.g. by adjusting respiratory volumes (intubated patients) or by pain reduction (patients with peridural/local anaesthesia).
- In cases with proper fragmentation, maintain energy level.
- In cases with proper focus positioning on the stone and a lack of visible fragmentation, energy levels must be increased. Monitor for cutaneous hematoma → immediate reduction of energy levels.

Ureteral Stone Proximal

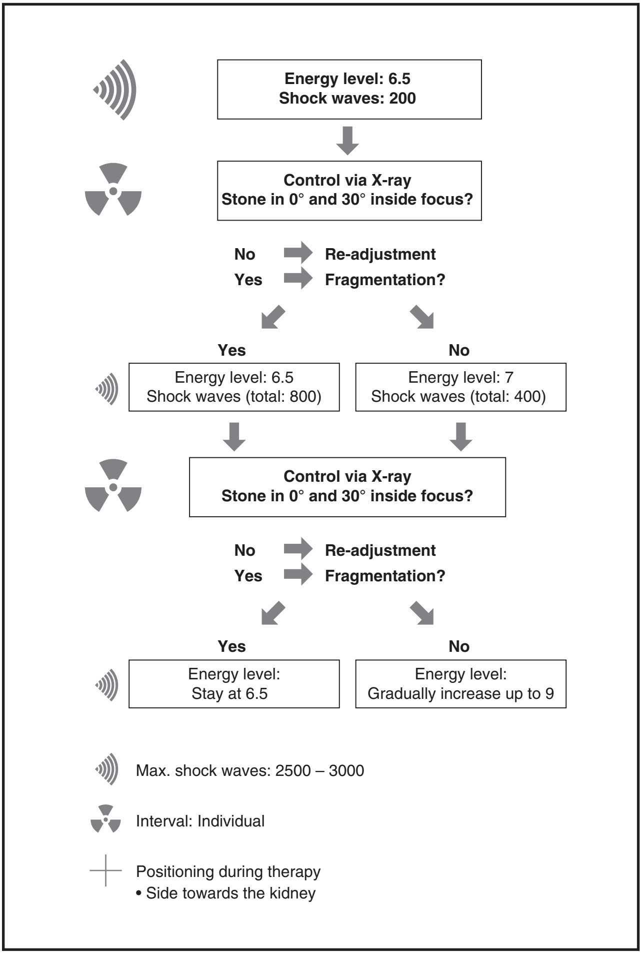
Preparation

Patient position	Supine position
Focus size at adjustment	Small
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	Surface towards the kidney: (see arrow Fig. 2.6)
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



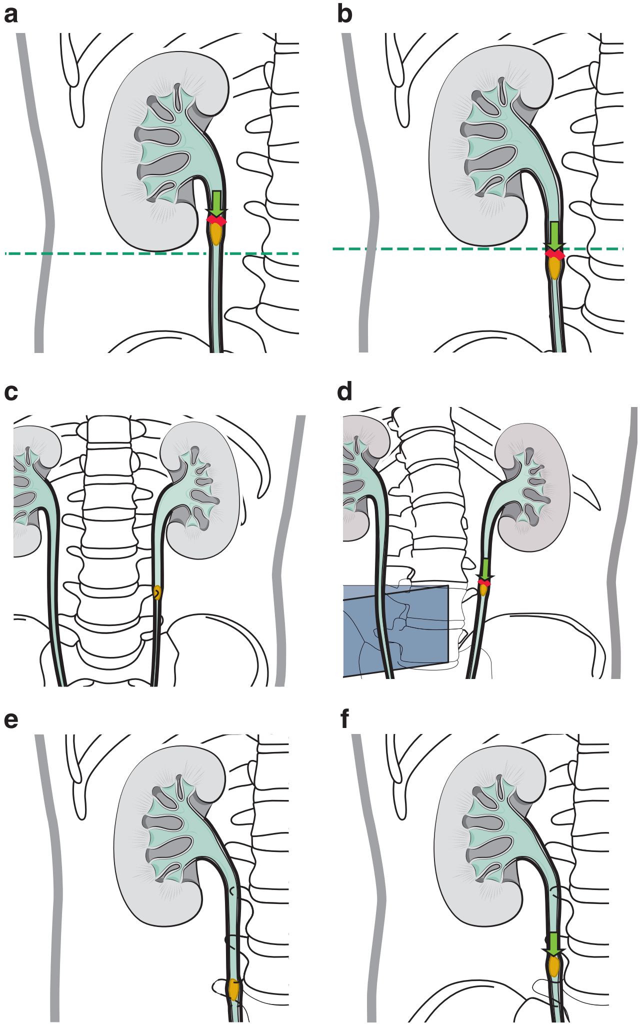


FIGURE 2.6 (**a**) Proximal ureter stones shielded by kidney parenchyma (stone above green line). (**b**) Proximal ureter stones distal of the lower kidney pole (stone below green line). (**c**) Minor part of the stone is covered by a bony structure. (**d**) Wedge-shaped cushion allows for treatment in supine position. (**e**) Stone with predominant bone coverage. Consider stone relocation or therapy in prone position. (**f**) Begin SWL at the side towards the kidney. Consider SWL in prone position

Tips & Tricks

- Careful therapy planning, as there is a risk of distal stone migration: discuss prone vs. supine position; keep positioning devices (e.g. wedges) on hand.
- Maximum shock waves for proximal ureter stones shielded by kidney parenchyma: 2500 (Fig. 2.6a, stone above green line)
- Maximum shock waves for proximal ureter stones distal of the lower kidney pole: 3000 (Fig. 2.6b, f, stone below green line).
- If only a minor part of the stone is covered by a bony structure (Fig. 2.6c) wedge-shaped cushions can be placed underneath the opposite side of the pelvis in order to move the stone out of the bony structure and allow for treatment in supine position (Fig. 2.6d). A complete visualisation after adjustment and during the complete therapy procedure (consider stone movement) is prerequisite before starting therapy in supine position.
- In case of predominant stone coverage (Fig. 2.6e): consider stone relocation (push) or therapy in prone position.
- All aspects must be adjusted, in order to avoid shock wave absorption (keep positioning devices on hand).
- Begin SWL at the side towards the kidney (Fig. 2.6d, f, green arrow), as this is the largest boundary surface between stone and urine (Fig. 2.6d, red area). Penetration of urine into the stone results in further enlargement, which optimises the efficacy of the shock wave energy and, thus, fragmentation.
- During breathing movements, the focus must always be targeted to the upper third of the stone volume. Excessive breathing movements (volumes > 500 mL) result in shock waves outside the focus and optimisation is required, e.g. by setting volumes (intubated patients) or by pain reduction (patients with peridural/local anaesthesia).
- Adjustment of energy levels is based on disintegration results. If the first 200 shock waves do not lead to visible results, energy levels must be increased instantly.

- Active treatment: continuous observation of fragment situation in order to prevent untargeted shock waves in cases of stone/fragment dislocation.
- Focus for proximal ureter stones shielded by kidney parenchyma: large
- Focus for proximal ureter stones distal of the lower pole of the kidney: small
- Stones between two transverse processes must be checked on a regular basis, in order to identify and response to stone migration, overlapping of bony structure and fragmentation, respectively.
- In cases of proper fragmentation, keep X-ray collimation large for overview
- In cases of bad fragmentation or lack of effect: keep X-ray collimation small.

Ureteral Stone Mid-Level

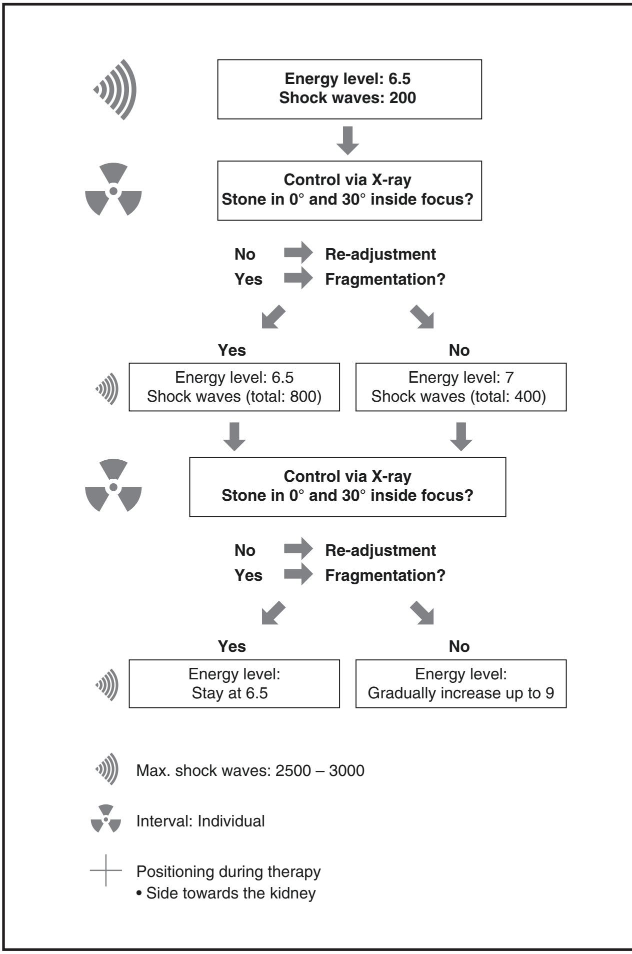
Preparation

Patient position	Supine position and/or prone position
Focus size at adjustment	Small
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	Surface towards the kidney
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



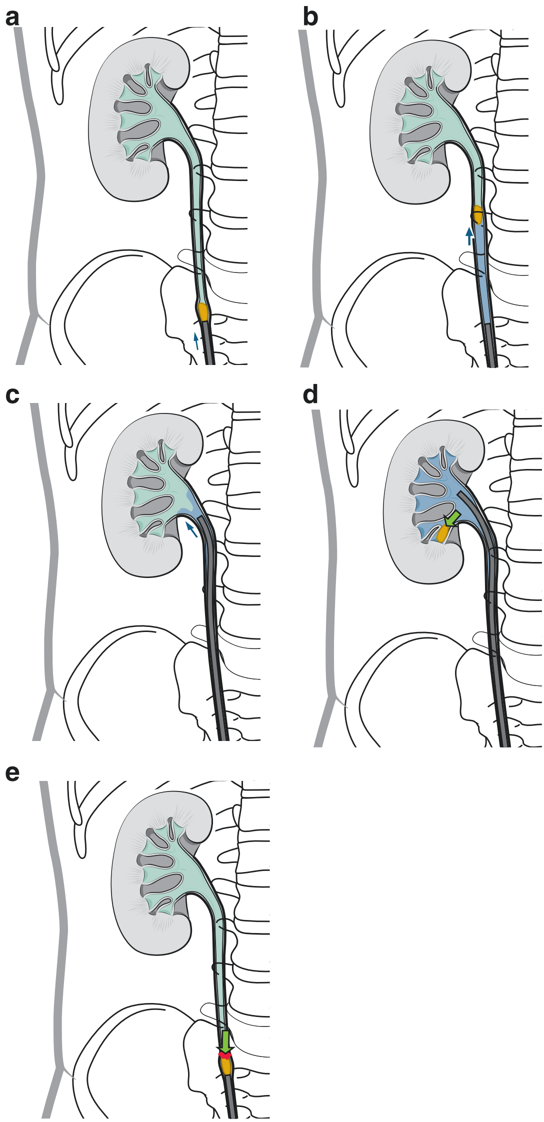


FIGURE 2.7 (**a**–**d**) Retrograde push of a medium-sized ureteral stone until renal pelvis-calcyceal system. (**e**) SWL of medium-sized ureteral stones after insertion of a ureter catheter beneath the stone in prone position

Tips & Tricks

- In principle, the treatment process is identical to that with proximal stones.
- Careful planning, after considering pros and cons of different positioning and treatment options, is essential for good fragmentation (consider ureteral catheter (UC)).
  - Relocate stone from bone window (push) (Fig. 2.7a–d)
    SWL in *supine* position with UC *in situ*
  - SWL in *prone* position
    Directly without UC
    After UC positioning (Fig. 2.7e)
  - In case of stones in the distal sacrum aspect, planning should consider primary/secondary ureteral catheter.

Prior to direct SWL in prone position, retrograde stone mobilisation can be attempted in order to remove the stone from the bone window (Fig. 2.7a–d). For this purpose, a UC with central opening is placed via cystoscopy distal to the stone. With the injection of a isotonic sodium chloride solution/glycine mixture (60%:40%) the stone may be pushed cranially. Be cautious particularly in patients with dilated renal pelvis because of the risk of forniceal rupture. Moreover, perioperative antibiotic treatment should be administered with this kind of manipulations. Do not use contrast media, since it would make subsequent stone assessment impossible. In case of successful mobilisation out of the overlapping bony area, the UC should be left *in situ* underneath the stone in order to prevent dislocation. If the push cannot be performed, do not force it. Either switch modality (URS) or switch into prone position following UC positioning underneath the stone (Fig. 2.7e). Ensure proper fixation of the UC to a urinary catheter in order to prevent UC dislocation during patient positioning. Treatment in prone position is a big challenge, since overlapping bony structures complicate stone detection. Prior UC positioning underneath the stone may be helpful in this situation.

- Maximum shock waves for ureter stones: 3000
- Maximum shock waves for stones pushed back into the kidney: 2500
- Initiate SWL at the side towards the kidney, as this is the largest boundary surface between stone and urine (Fig. 2.8). Penetration of urine into the stone results in further enlargement, which optimises the efficacy of the shock wave energy and, thus, fragmentation.
- Treatment of hard or impacted stones require treatment initiation with high energy levels. As soon as the length of the stone has changed, therapy can be continued with lower energy levels. If the first 200 shock waves lead to visible changes of the stone energy level in maintained.
- Adjustment of energy levels is based on disintegration results. If the first 200 shock waves do not lead to visible results, energy levels must be increased instantly.
- Active treatment: continuous observation of fragment situation in order to prevent untargeted shock waves in cases of stone/fragment dislocation.
- During breathing movements, the focus must always be targeted to the upper third of the stone volume. Excessive breathing movements (volumes > 500 mL) result in shock waves outside the focus and optimisation is required, e.g. by decreasing respiratory volumes (intubated patients) or pain reduction (patients with peridural/local anaesthesia).
- In cases of proper fragmentation, keep X-ray collimation large for overview (monitoring of potential fragment dislocation); in such a case a 30 degree setting and/or X-ray imaging may provide better results than fluoroscopy in 0 degree.
- In cases of bad fragmentation or lack of effect: keep X-ray collimation small.

Ureteral Stone Distal

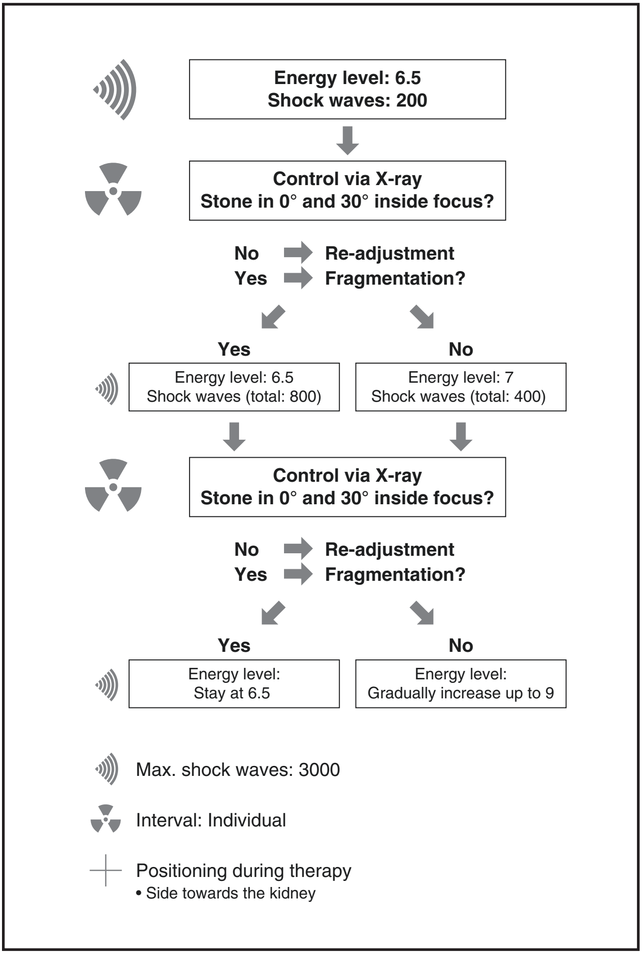
Preparation

Patient position	Supine position and/or prone position
Focus size at adjustment	Small
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	Surface towards the kidney: (see arrow Fig. 2.8)
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



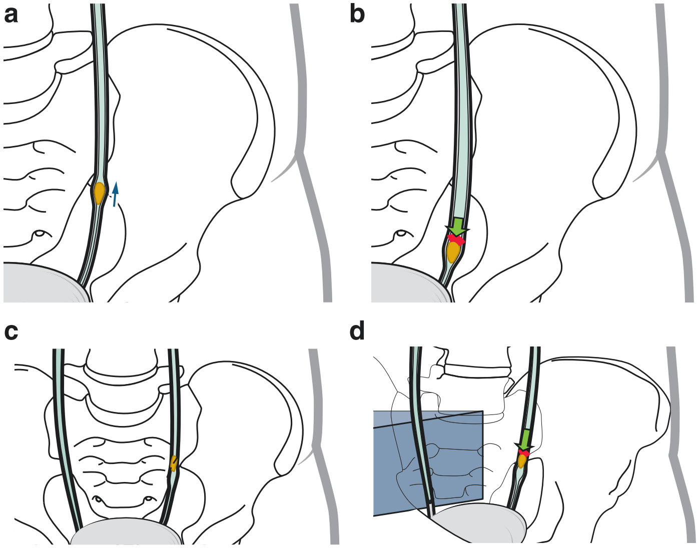


FIGURE 2.8 (**a**) Risk of stone migration into the bone window during treatment. (**b**) Prevesical stones treated in supine position. (**c**) Stones located close to the sacrum or covered by bony structures require treatment in prone position. (**d**) Using positioning devices sometimes allows for treatment in supine position

Tips & Tricks

- Careful patient positioning: consider risk of stone migration during treatment into the bone window (Fig. 2.8a): prevesical stones can usually be treated in supine position (Fig. 2.8b). Stones located close to the sacrum or covered by bony structures should be treated in prone position (Fig. 2.8c). However, using positioning devices (e.g. wedges) may allow treatment in supine position (Fig. 2.8d).
- Initiate SWL at the side towards kidney (Fig. 2.8b, d), as this is the largest boundary surface between stone and urine (red area Fig. 2.8d). Penetration of urine into the stone results in further enlargement, which optimises the efficacy of the shock wave energy and, thus, fragmentation.

- During breathing movements, the focus must always be targeted to the upper third of the stone volume. Excessive breathing movements (volumes > 500 mL) result in shock waves outside the focus and optimisation is required, e.g. by decreasing respiratory volumes (intubated patients) or pain reduction (patients with peridural/local anaesthesia).
- Active treatment: continuous observation of fragment situation in order to prevent untargeted shock waves in cases of stone/fragment dislocation.
- Adjustment of energy levels is based on disintegration results. If the first 200 shock waves do not lead to visible results, energy levels must be increased instantly.
- Treatment of hard or impacted stones or of stones persisting for extended periods of time must be initiated with high energy levels. As soon as the length of the stone has changed, therapy can be continued with lower energy levels.
- In cases of proper fragmentation, keep X-ray collimation large for overview (monitoring of potential fragment dislocation); in such a case a 30 degree setting and/or X-ray imaging may provide better results than fluoroscopy in 0 degree.
- In cases of bad fragmentation or lack of effect: keep X-ray collimation small.
- In case of proper fragmentation energy levels should not be increased to prevent unnecessary stone/fragment dislocation.
- Bilateral ureteral stone treatment must only be considered following optimal lithotripsy performance on the first site. In cases with intermediate results: schedule a second treatment session.

Special Situations

Uric Acid Stones

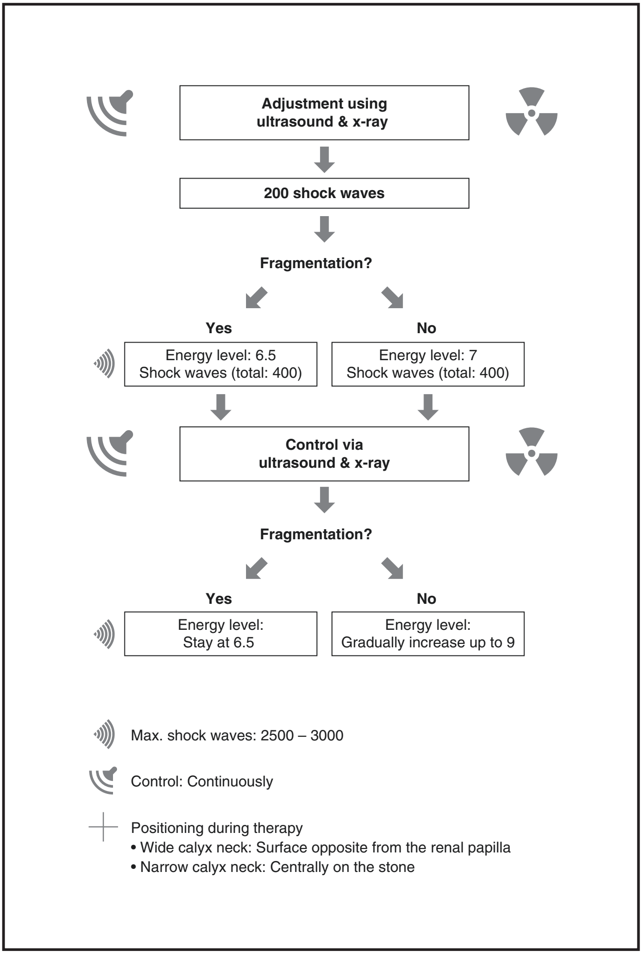
Preparation

Patient position	Supine position
Focus size at adjustment	Large and/or small
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	complicated; if possible, select stone portion facing the kidney (Fig. 2.9a, b)
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



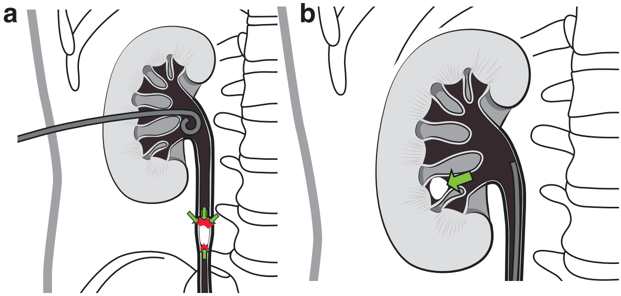


FIGURE 2.9 Antegrade via percutaneous nephrostomy (**a**) or retrograde via ureteral catheter (**b**) contrast media application and detection of contrast media gaps is the method of choice

Tips & Tricks

- Only few data and visual examples are available with regard to SWL in patients with uric acid stones that cannot be detected and visualised by means of imaging. Due to the lack of visualisation, the procedure is demanding and only rarely conducted. SWL in uric acid stone has its eligibility in increasing stone surface prior to and during oral chemolitholysis, especially in heterogeneous stones involving oxalate fraction.
- Ultrasound is suitable to detect uric acid stones within the kidneys. Therefore, SWL systems with integrated ultrasound unit can be used for sonographically guided SWL.
- If no ultrasound is available or in case of ureteral stones, antegrade via percutaneous nephrostomy (PNS) (Fig. 2.9a) or retrograde via ureteral catheter (UC) (Fig. 2.9b) contrast media application and detection of contrast media gaps are the methods of choice.
- For better orientation, known landmarks from CT scans (transverse processes, calcifications) will mentally be fused with the current X-ray positioning. This should be performed prior to contrast media administration in order to visualise contrast media gaps immediately under fluoroscopy.
- Maximum shock waves for kidney stones: 2500
- Maximum shock waves for ureteral stones: 3000
- Focus for kidney stones: large
  Focus for ureteral stones: small

Pelvic Kidney and Kidney Transplants

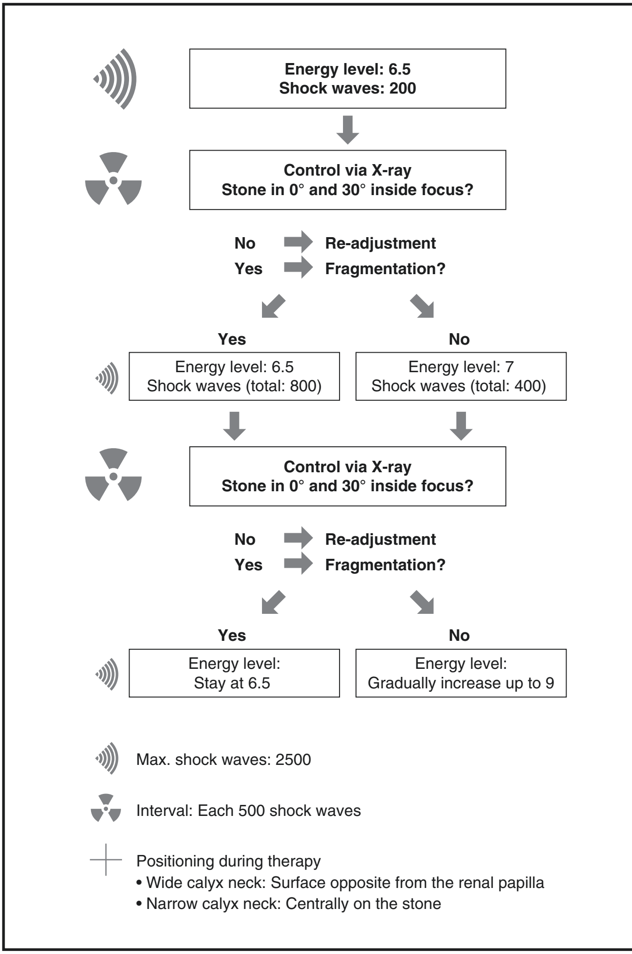
Preparation

Patient position	Prone position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrow Figs. 2.1a, b and 2.10 • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



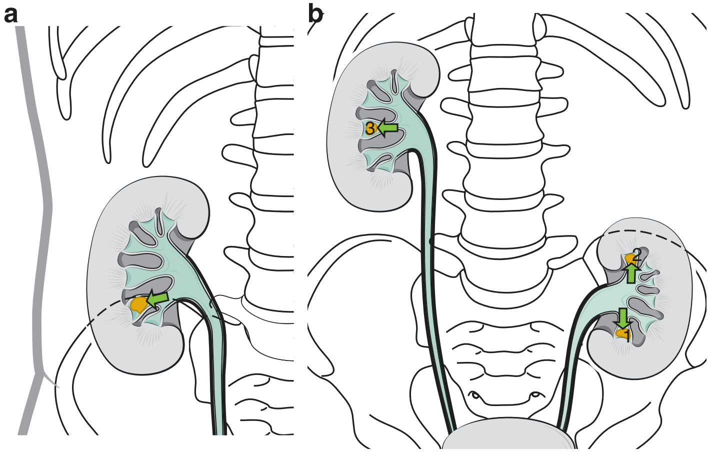


FIGURE 2.10 (**a**) SWL of a pelvic kidney or a kidney transplant in prone position. (**b**) Simultaneous SWL of one orthotopic and one pelvic kidney in prone position

Tips & Tricks

- Stone treatment in patients with pelvic kidney or kidney transplants in prone position requires laxative preparation (Fig. 2.10a).
- Trial positioning helps to identify problems and allows for specific preparation.
- In cases of simultaneous stone treatment of one orthotopic and one pelvic kidney, therapy should be conducted in prone position in order to avoid intraoperative repositioning (Fig. 2.10b).
- Maximum number of shock waves 2500 for the kidney with the higher and 800 for the kidney with the lower stone burden.
- When bilateral therapy is required, stone volume in the kidney with the lower stone burden must not exceed 8–10 mm. Otherwise sufficient fragmentation may not be

achieved with the 800 available shock waves. In case of higher stone burden, it is preferable to schedule two sessions.

- In cases of proper fragmentation, keep X-ray collimation large for overview (monitoring of potential fragment dislocation).
- In cases of bad fragmentation or lack of effect, keep X-ray collimation small.
- Stone migration within the focus should not exceed 1 cm. Excessive breathing movements (volumes > 500 mL) result in shock waves outside the focus and optimisation is required, e.g. by adjusting respiratory volumes (intubated patients) or by pain reduction (patients with peridural/local anaesthesia).
- In cases with proper focus positioning on the stone and a lack of visible fragmentation, energy levels must be increased. Monitor for cutaneous hematoma → immediate reduction of energy levels.
- In case of proper fragmentation energy levels should not be increased to prevent unnecessary stone/fragment dislocation.
- When fragmentation proves to be efficient, therapy may be finalized prior to achieving the maximum amount of shock waves.

Horseshoe Kidney

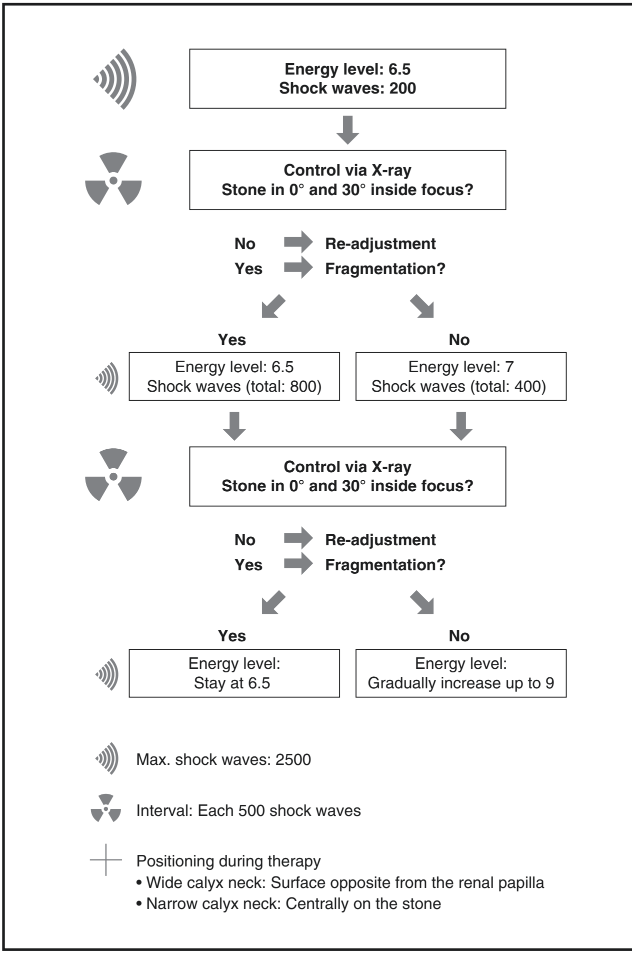
Preparation

Patient position	Prone position or supine position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrow Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



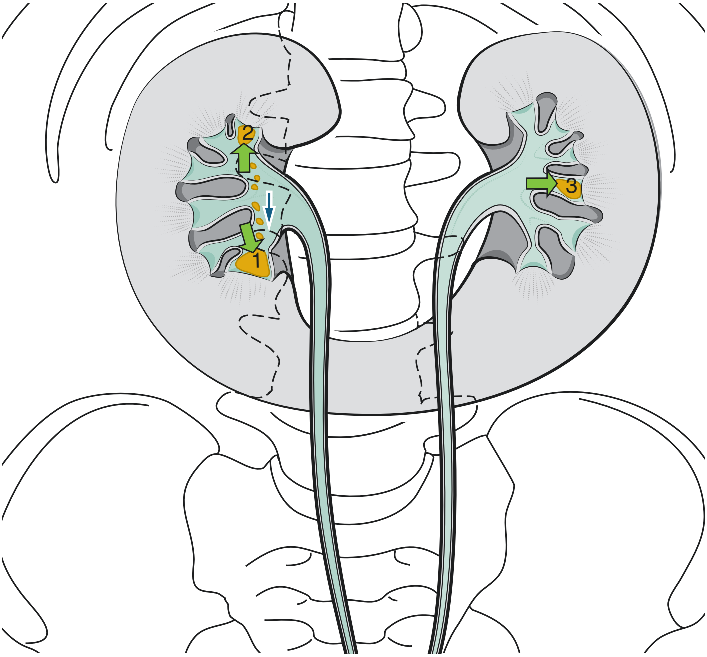


Figure 2.11 Stones in medium or upper calyx groups may dislocate into lower calyx systems

Tips & Tricks

- Horseshoe kidneys are treated either in prone or in supine position, depending on intrarenal stone location. Calyceal anatomy in relation to stone location must be visualised prior to treatment, also identifying calyxes in which disintegrated fragments may potentially dislocate. Risk of bony overlapping is particularly higher with stones in lower calyx groups; therefore, those patients should be preferably treated in prone position. Stones in medium or upper calyx groups may dislocate into lower calyx systems due to lithotripsy, and it might then no longer be possible to treat them in supine position (Fig. 2.11).
- Trial positioning helps to identify problems before anaesthesia.

- In cases of simultaneous stone treatment of one orthotopic and one pelvic kidney therapy should be conducted in prone position in order to avoid intraoperative repositioning.
- Maximum number of shock waves 2500 for the kidney with the higher and 800 for the kidney with the lower stone burden.
- When bilateral therapy is required, stone volume in the kidney with the lower stone burden should not exceed 8–10 mm. Otherwise sufficient fragmentation may not be achieved with the 800 remaining shock waves. In case of a higher stone burden within the second kidney it is preferable to schedule two SWL sessions.

Duplex Kidney

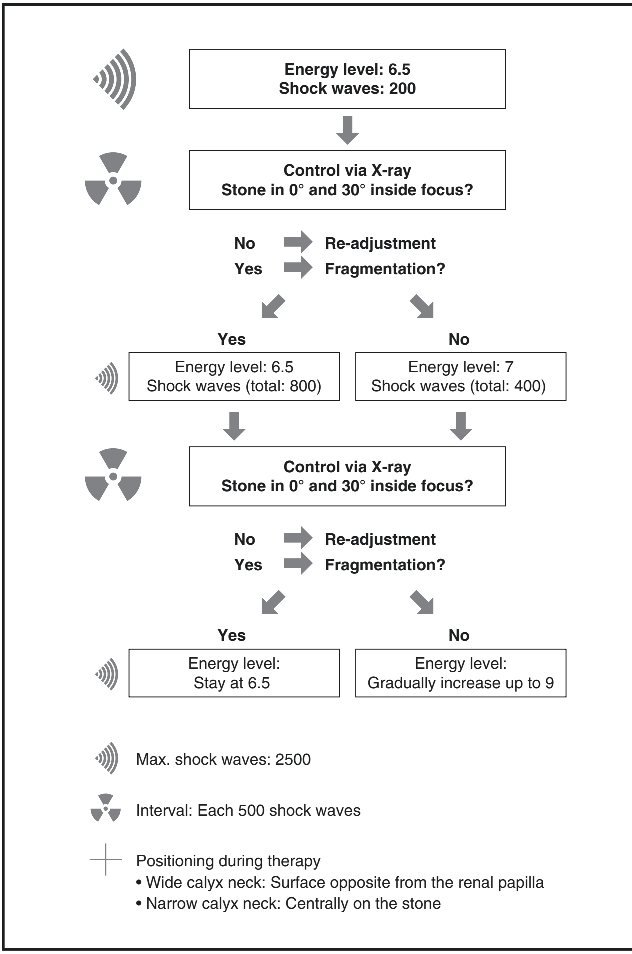
Preparation

Patient position	Supine position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrow Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



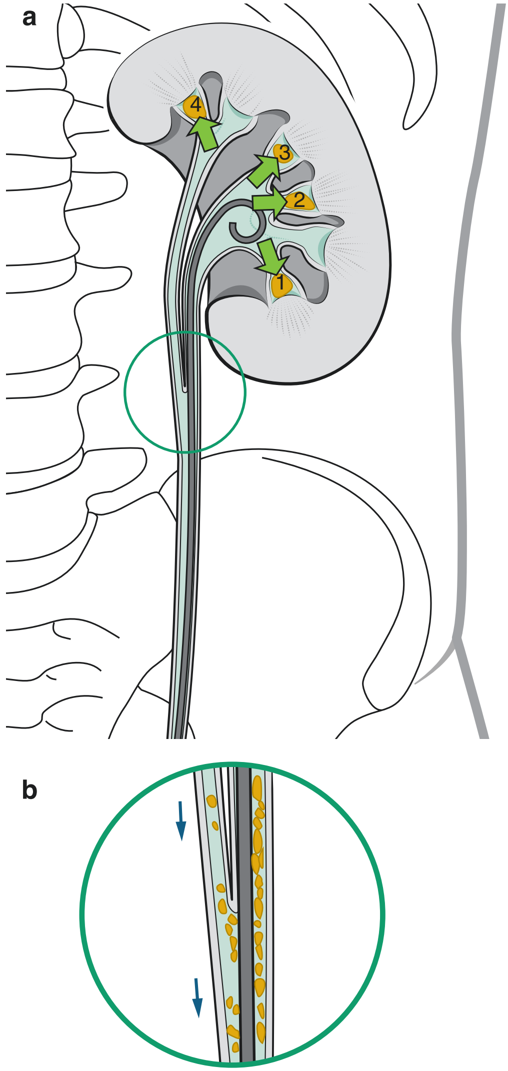


FIGURE 2.12 Double-j stenting into the system with high stone burden may be helpful in order to protect the uretero-ureteral junction and facilitate clearance of disintegrated stone fragments

Tips & Tricks

- In principle, stones in duplex kidney systems are treated the same way as in wide calyx systems with one ureter (see relevant chapters).
- Consider pre- or postoperative double-j stent insertion into the system with higher stone burden (Fig. 2.12a, b).

Spinal Deformations

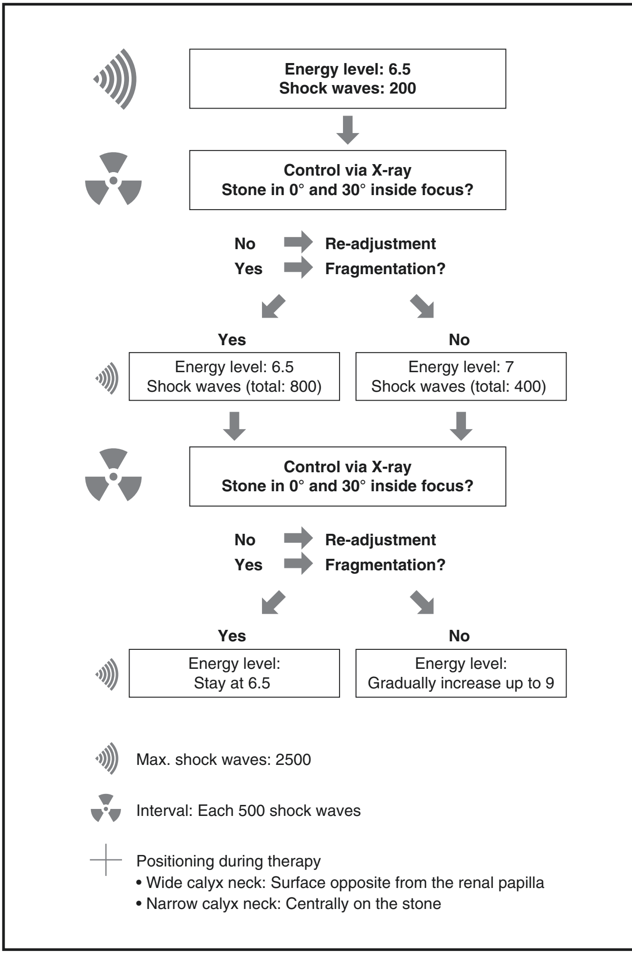
Preparation

Patient position	Prone position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone	According to calyx neck anatomy: see arrow Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure



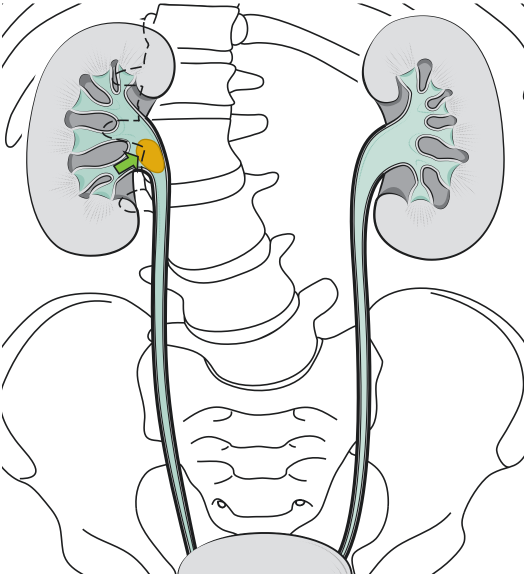


FIGURE 2.13 SWL of stone with spinal deformations

Tips & Tricks

- The same prerequisites apply as described in chapters "stones shielded by bony structures" and "stones in the mid ureter".
- Trial positioning helps to identify problems before anaesthesia.
- Patients with concomitant funnel chest (pectus excavatum sive infundibulum) require lateral stabilisation using positioning cushions.
- If required due to deformities, the coupling cushion must be further extended to ensure continuous contact.

Expert Situations

SWL in Children

Preparation

Patient position	Supine or prone position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Patient position, focus size at adjustment and initial cross hair positioning on the stone are adjusted in the same way as in adult patients (see relevant chapters).

Start of therapy

Energy level at beginning	3.5
Shock waves at beginning	100

Adjustment for children on a Storz lithotripter (other lithotripter: contact manufacturer)

	Energy level start	**Energy level max.**	**Shock waves before first control**
Kidney	3	6.5	100
Ureter	4.5	6.5	100

			Max. amount of shock waves	
Age	**Focus**	**X-ray collimation**	**Kidney**	**Ureter**
1–5 years	large	small	1200–1400	1400–1500
6–7 years	large	small	1500	1600
8–12 years	large	small	1600	1700
13–15 years	large	small	1700–1800	1800–2000

Tips & Tricks

- SWL in children demands careful preparation in order to ensure an efficient therapy and to avoid collateral damage.
- Generally, stones are treated according to the same principles as described for adults. However, energy levels and number of shock waves applied need to be adjusted to the children's age. Therefore, it is crucial to be aware of the energy levels delivered by different SWL generators (if in doubt contact the manufacturer).
- An aluminum foil is placed below the thorax for lung protection. The foil is mounted at the deepest level of the lung during inspiration.
- For babies and infants (1–5 years) fixation using elastic tapes my help to prevent movement during SWL.
- Try to keep X-ray collimation narrow.
- In cases with proper focus positioning on the stone and a lack of visible structural changes, energy levels must be increased. Monitor for cutaneous hematoma → immediate reduction of energy levels.
- In cases of proper fragmentation energy levels should not be increased to prevent unnecessary fragment dislocation.
- When fragmentation proves to be efficient, therapy may be finalized prior to achieving the maximum amount of shock waves.
- No bilateral synchronous treatment recommended.

Bile Duct and Pancreatic Duct Stones

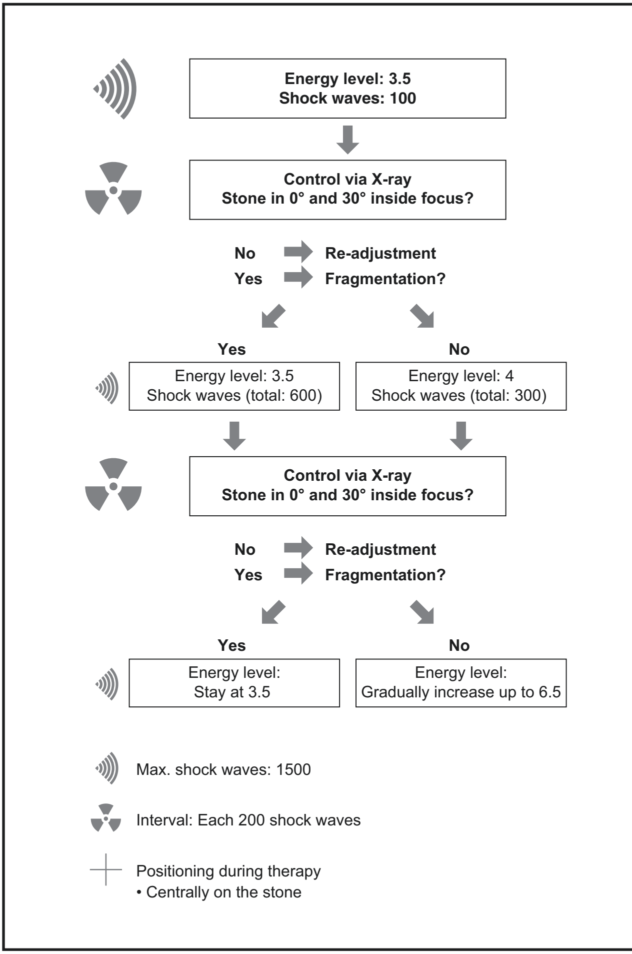
Preparation

Patient position	Prone position
Focus size at adjustment	Large

Start of therapy

Initial cross hair positioning on the stone	Centrally, on the stone
Energy level at beginning	3.5
Shock waves at beginning	100

Therapeutic procedure



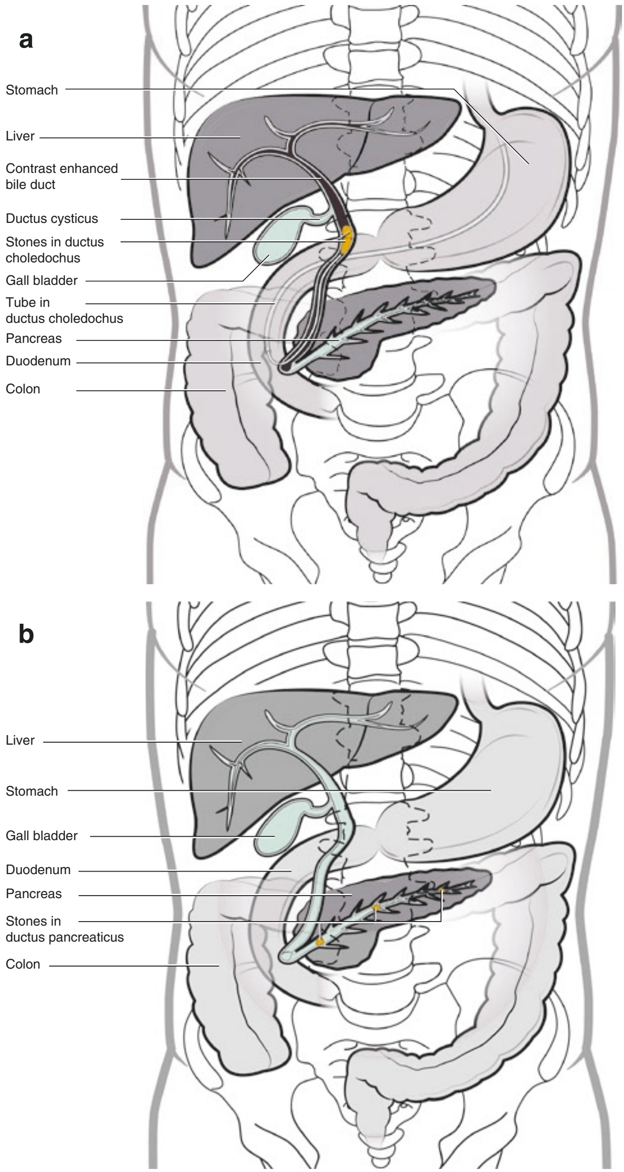


FIGURE 2.14 SWL of bile duct (**a**) and pancreatic duct (**b**) stones. Note the endoscopic placed nasogastric tube for better visualization

Tips & Tricks

- Trial detection allows for assessment of stone visualisation before anaesthesia.
- Therapy must be conducted in prone position.
- Antibiotics should be administered before therapy.
- For bile duct stones contrast media via endoscopic placed tube allows better visualisation and to rinse with isotonic sodium chloride solution after therapy.

SWL in Combination with PCNL

Preparation

Patient position	Supine position
Focus size at adjustment	Large
Furosemide administration	10 min prior to therapy initiation

Start of therapy

Initial cross hair positioning on the stone:	According to calyx neck anatomy: see arrow Fig. 2.1a, b • Wide calyx neck: surface opposite from the renal papilla • Narrow calyx neck: centrally, on the stone
Energy level at beginning	6.5
Shock waves at beginning	200

Therapeutic procedure

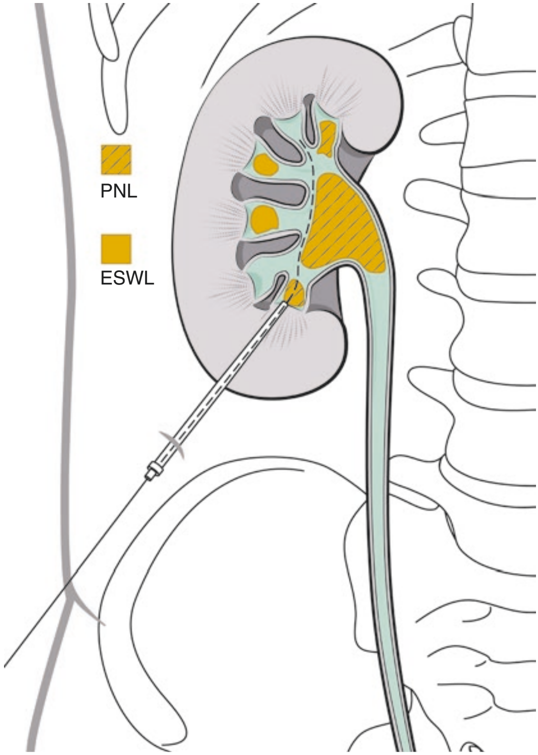


FIGURE 2.15 SWL pre- or post PCNL to achieve complete stone clearance

Tips & Tricks

- SWL is usually performed after PCNL for the treatment of residual and inaccessible fragments. However, SWL can also be performed before PCNL. In terms of timing of post-PCNL SWL there appears to be no difference between immediate SWL after PCNL compared to delayed SWL (1 week).

  - Be aware of exact stone positions and surrounding anatomy (number of calyxes and their relational positions, potential sites of fragment distribution/dislocation, anatomy of calyx neck) → create a schematic drawing (see blank schematic drawing Fig. A1, Appendix).
  - Consider the maximum amount of possible shock waves (2500) and prioritise. Rather than performing an insufficient "treatment attempt" of all stones, shock waves should be used for the complete therapy of selected stones, and a second SWL session may be scheduled.
  - Plan individual cross hair positioning for each stone at treatment initiation based on stone position and surrounding calyx anatomy. In cases of narrow calyceal necks start treatment in the centre of the stone. In cases of wide calyceal necks start treatment at the opposite of the renal papilla.
  - Constant observation and overview of/on the fragmentation status allows for prompt response to changes.
    - Consider trial detection for small stones with low density.

- X-ray collimation during reorientation or check-up: large.
- Focus for kidney stones: large.
- Stone migration within the focus should not exceed 1 cm. Excessive breathing movements result in shock waves outside the focus and optimisation is required, e.g. by adjusting respiratory volumes (intubated patients) or by pain reduction (patients with peridural/local anaesthesia).
- In cases with proper fragmentation, maintain energy level.
- In cases with proper focus positioning on the stone and a lack of visible fragmentation, energy levels must be increased. Monitor for cutaneous hematoma → immediate reduction of energy levels.

Reference

1. Skuginna V, et al. Does stepwise voltage ramping protect the kidney from injury during extracorporeal shockwave lithotripsy? Results of a prospective randomized trial. Eur Urol. 2016;69(2):267–73.

Chapter 3
SWL Treatment Examples

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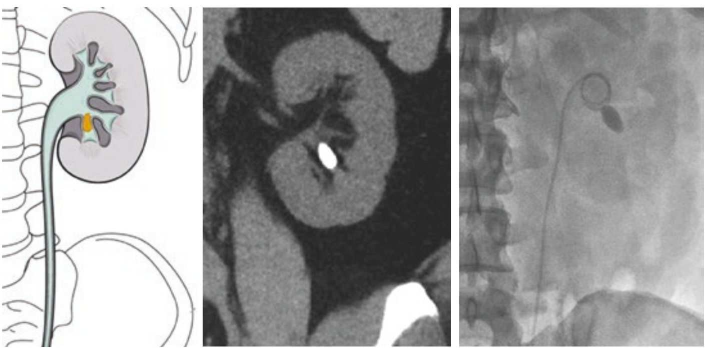
R. Schmutz et al., *Extracorporeal Shock Wave Lithotripsy*,
In Clinical Practice, https://doi.org/10.1007/978-3-319-77640-8_3

Solitary Unilateral Kidney Stone Pyelon/Lower Calyx

Patient history

46-year-old lady with recurrent left sided flank pain during a vacation. CT revealed a 16 × 9 × 9 mm stone in the lower calyx (>1000 HU) and a double-j stent was placed.

Starting position



Schematic drawing CT scan before DJ KUB before SWL

Individual strategy

Due to stone size and location SWL, secondary flexible URS and Mini-PCNL were considered as treatment options.

SWL vs. flexible URS

Regarding the total stone volume flexible URS would necessitate not only laser-disintegration but also laser-vaporisation, meaning to leave stone fragments behind. However, disintegration without complete stone clearance can also be achieved using SWL, while SWL has no risk for ureteral injury by frequent insertion and removal of any instrument despite the placement of an access-sheath.

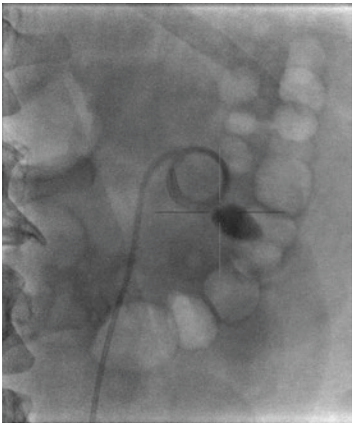
SWL vs. Mini-PCNL

Compared to a percutaneous procedure SWL is less invasive with lower rates of complications. However, the advantage of a PCNL is the combination of disintegration and complete removal of the stone at the same time, while SWL only facilitates the disintegration process. The relatively big stone volume, the location in the lower pole as well as the high density of >1000 HU are also known negative predictors for SWL stone free rates, especially compared to stone free rates with PCNL manoeuvres. Moreover, secondary intervention after successful SWL disintegration but incomplete stone clearance can be complicated. Having fragments spread over multiple calyces may limit secondary PCNL while multiple very small fragments prolongate flexible URS interventions. Placing a double-j stent before SWL may prevent renal colic and steinstrasse, while it induces lower urinary tract symptoms (LUTS), hematuria, urinary tract infection, and lowers the stone-free rate. All specific advantages and disadvantages were discussed with the patient, however she refused to undergo PCNL due to its invasiveness. Therefore, SWL with previous double-j stent placement was performed.

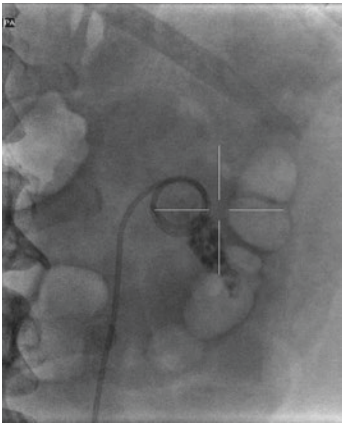
- Be aware that the use of contrast media during double-j stent placement may limit visibility. While this might not be a problem of the intact stone, residual contrast media will limit evaluation of smaller fragments during therapy.
- Keep X-ray collimation wide to realize a potential fragment dislocation during therapy. Do not unnecessarily increase energy levels in case of good fragmentation.
- Be aware of the situation at the ureteropelvic junction and within the ureter. Treat ureteral blocking by big fragments in order to allow urinary drainage and fragment passage.

Therapeutic procedure

Stone pyelon/lower calyx	
Energy level	**Shock waves**
6.5	200
7.5	1800
8	500

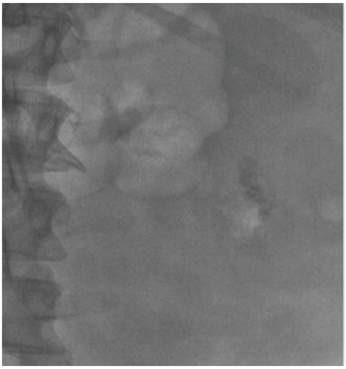


Beginn at the surface opposite of the renal papilla.

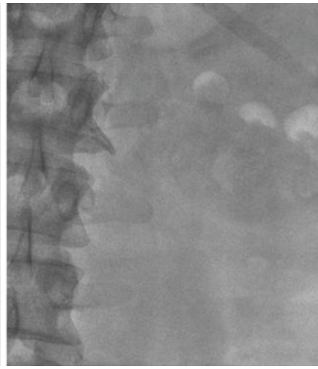


After 2500 shock waves fragments are kept in place by appropriate cross hair position.

Results



1st day after SWL. No visible ureteral fragments



3 months after SWL. No residual fragments, no need for secondary intervention.

Comments

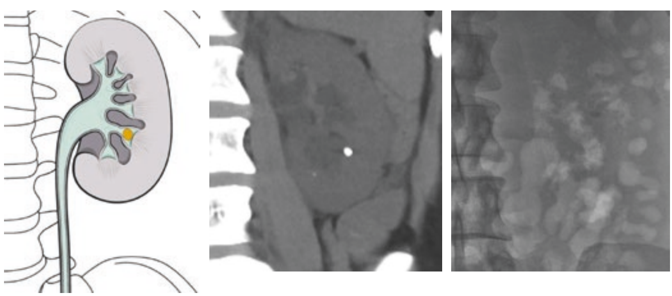
Stone analysis revealed 80% calcium oxalate dihydrate and 20% calcium oxalate monohydrate.

Solitary Unilateral Kidney Stone Lower Calyx

Patient history

51-year-old lady with spontaneous passage of a left sided ureteral stone and concomitant stone in the left sided lower calyx group (4 × 4 × 3 mm, 980 HU). Note the dilatated calyces shown by CT scan. SWL was performed 2 weeks after the symptomatic episode.

Starting position



Schematic drawing CT scan KUB before SWL

Individual strategy

Due to stone size and location SWL and flexible URS were considered as treatment options.

SWL vs. flexible URS

Following the EAU guidelines both procedures, SWL and flexible URS could be used for stone clearance. However, SWL appears to be the less invasive procedure with fewer and less severe complications.

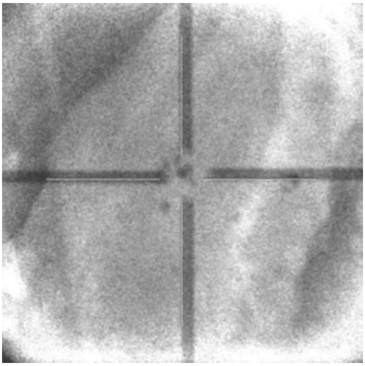
- Be aware of impaired visibility due to intestinal gas. Consider laxative preparation.

- Utilize all available images and prepare treatment by schematic drawing prior to beginning.
- Use landmarks (vertebral bodies, ribs) for orientation and their relation to the stone.
- Be aware of stone migration due to excessive breathing movements, especially during treatment of small stones.
- In case of readjustment of the stone into the focus do not forget to also readjust in the z-axis (30° fluoroscopy).
- In case of proper fragmentation therapy can be finalized prior to achieving the maximum amount of 2500 shock waves

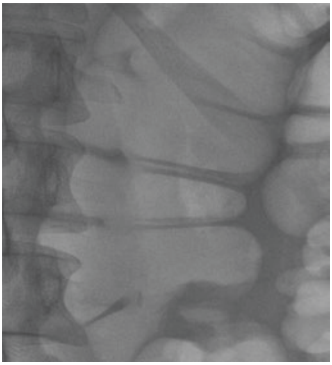
Therapeutic procedure

Stone lower calyx	
Energy level	**Shock waves**
6.5	1200
7.0	550
7.5	450

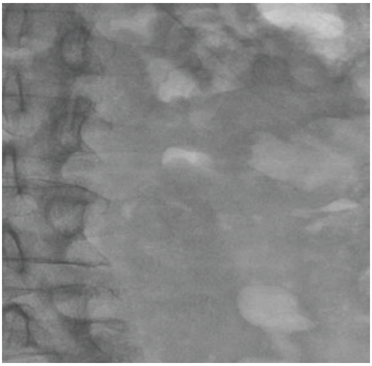

Visualization utilizing landmarks (vertebral body). Note the stone on the right side of the vertical cross hair position.


After 1750 shock waves: fair fragmentation, additional 450 shock waves with increased energy level (7.5) were applied.

Results



1st day after SWL. Note the residual fragments in the lower calyx.



3 months after SWL. No residual fragments, no need for secondary intervention.

Comments

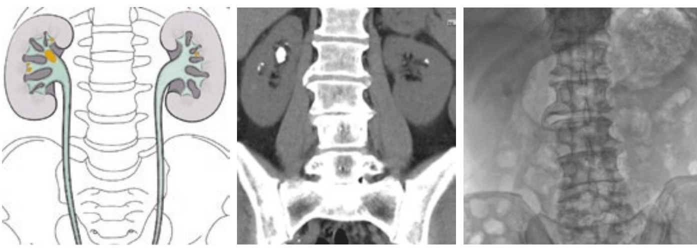
Stone analysis revealed 80% calcium oxalate dihydrate and 20% carbonate apatite. Later, the patient was diagnosed with renal tubular acidosis.

Multiple Bilateral Kidney Stones

Patient history

67-year-old male recurrent calcium oxalate stone former. CT scan revealed multiple stones in both kidneys with the higher stone burden on the right side (maximum size 15 × 12 × 9 mm, 1180 HU). Note the characteristic fused vertebral bodies allowing for intraoperative orientation.

Starting position



Schematic drawing   CT scan   KUB before SWL

Individual strategy

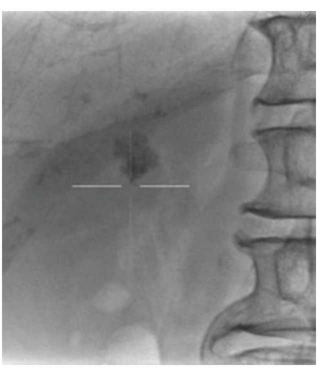
Due to stone size and location a combination of PCNL and postoperative SWL or bilateral SWL alone were considered as potential treatment options. Due to good SWL results in the patient's history bilateral SWL was performed.

- Be aware of impaired visibility due to intestinal gas. Consider laxative preparation.
- Utilize all available images and prepare treatment by schematic drawing prior to beginning.
- Use landmarks (vertebral bodies, ribs) for orientation and their relation to the stone.

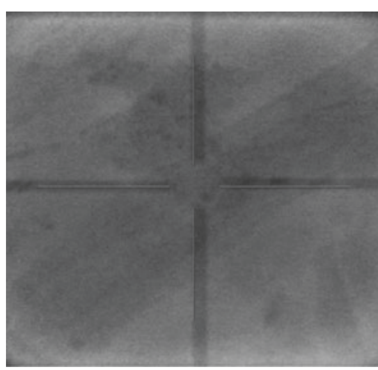
- Generate on table X-rays before swinging in the generator. Centre each stone into the focus and write down the coordinates for x-, y- and z-axis. Even though coordinates will deviate a bit after swinging in the generator it will help to facilitate cross hair positioning on the stone.
- Be aware of stone migration due to excessive breathing movements, especially during treatment of small stones.
- In case of readjustment of the stone into the focus do not forget to readjust in the z-axis (30° fluoroscopy).
- Start at the symptomatic side or at kidney with the higher stone burden.
- Be aware of a sufficient distribution of the available overall shock waves, e.g. 2500 shock waves on the first and 800 shock waves on the second side.

Therapeutic procedure

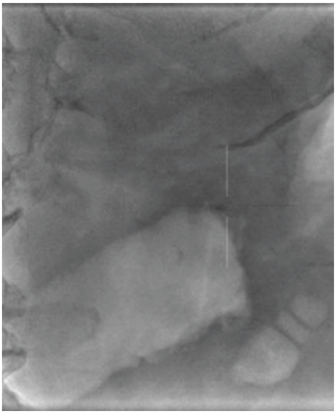
Stone right upper calyx		**Stone left mid calyx**	
Energy level	**Shock waves**	**Energy level**	**Shock waves**
6.5	1000	6.5	400
7.0	1500	7.0	400



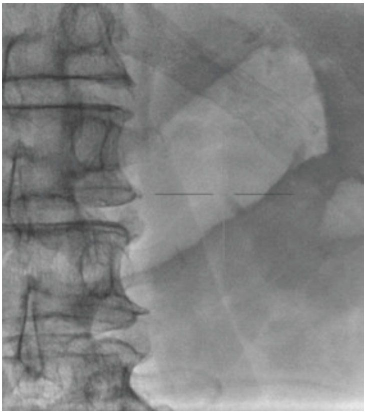
Begin at the right upper pole: Visualization utilizing characteristic vertebral body and rib. Note the position of the cross hair at the beginning



After 1750 shock waves: good fragmentation



Begin left side with impaired visualization.



Fast and sufficient fragmentation after 500 shock waves (energy level: 6.5).

Results

1st day after SWL

Comments

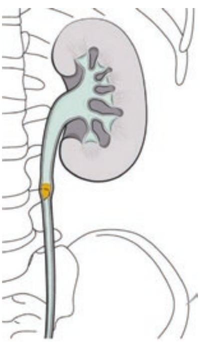
Due to residual fragments a secondary SWL was required 6 months after the first SWL.

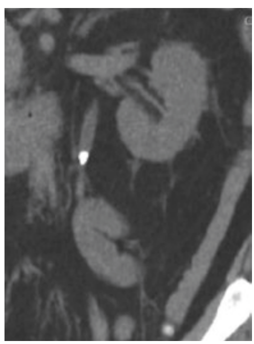
Ureteral Stone Proximal (Supine & Prone Position)

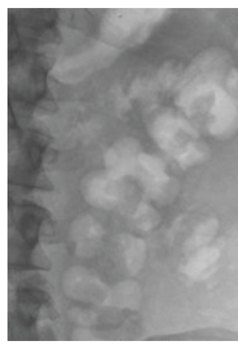
Patient history

The 66-year-old male was diagnosed with a symptomatic left sided proximal ureteral stone. CT scan revealed a 7 × 4 × 4 mm stone in the left proximal ureter, partly covered by a transverse process. Colleagues in a foreign hospital abroad performed SWL in supine position.

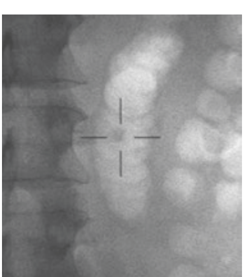
Starting position of the abroad performed SWL in supine position

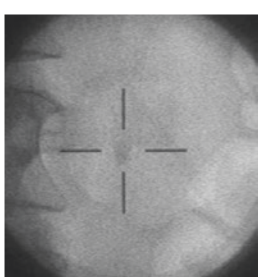

Schematic drawing


CT scan


KUB before SWL in supine position

Therapeutic procedure first SWL in supine position


Stone covered by transverse proc.

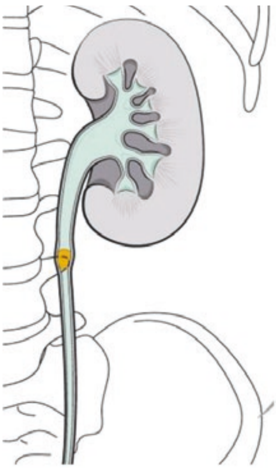

Bone coverage prevents disintegration

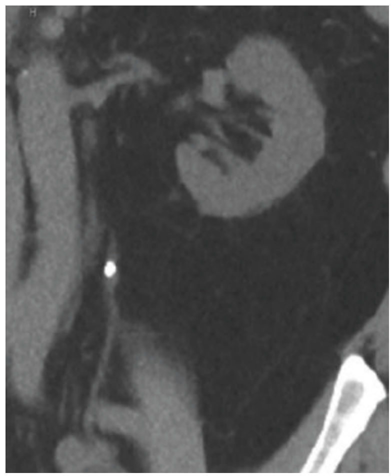

Persistence after 3000 shock waves

Course after abroad performed SWL

Recurrent left sided flank pain 3 month after first SWL in supine position. KUB and CT scan revealed an almost unchanged persistence of the stone.

Starting position


Schematic drawing


CT scan

Individual strategy

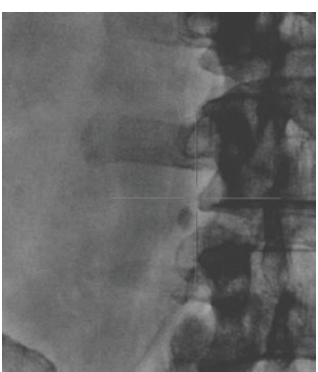
Due to stone position and the partly coverage by a transverse process, re-SWL in prone position or stone repositioning using a retrograde push manoeuvre followed by SWL in supine position were discussed. Due to good radiographic visibility of the stone and the less invasive nature, SWL in prone position was performed.

- Be aware of impaired visibility due to intestinal gas. Consider laxative preparation.
- Be aware that due to the body weight on the one hand and the surface pressure of the energy source on the other hand, the geometric precision of the stone *per se* will be slightly modified.

- Utilize all available images and prepare treatment by schematic drawing prior to beginning.
- Use landmarks (vertebral bodies, ribs) for orientation and their relation to the stone.
- Generate on table X-rays before swinging in the generator. Centre each stone into the focus and write down the coordinates for x-, y- and z-axis. Even though coordinates will deviate a bit after swinging in the generator it will help to facilitate cross hair positioning on the stone.
- In case of readjustment of the stone into the focus do not forget to readjust in the z-axis (30° fluoroscopy).
- Begin lithotripsy at the side towards the kidney (Fig. 2.6d, f, green arrow), as this is the largest boundary surface between stone and urine (Fig. 2.6d, red area). Penetration of urine into the stone results in further enlargement, which optimises the efficacy of the shock wave energy and, thus, fragmentation.

Therapeutic procedure

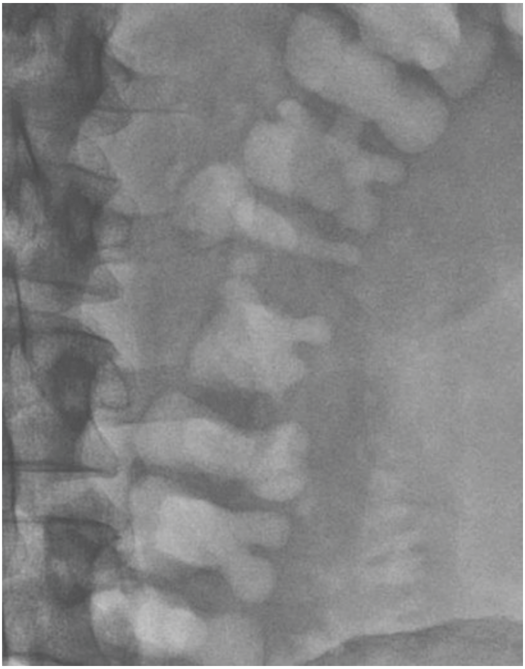
Stone proximal ureter	
Energy level	**Shock waves**
6.5	200
7.0	1200
7.5	800



Stone location during inspiration

Good disintegration after 2200 shock waves

Results



1st day after SWL with no residual fragments

Comments

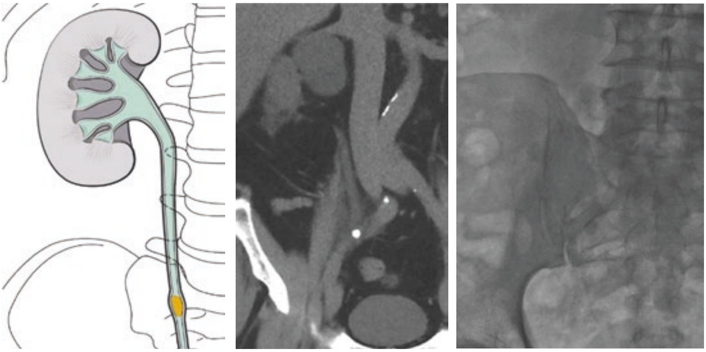
The symptom free patient refused to undergo radiography for local control 3 months postoperatively.

Ureteral Stone Mid-Level

Patient history

58-year-old male with symptomatic mid-level ureteral stone in projection of the sacrum (8 × 4 × 4 mm, 900 HU).

Starting position



Schematic drawing CT scan KUB before SWL

Individual strategy

Due to stone size and location SWL in prone position and flexible URS were considered as treatment options. SWL appears to be the less invasive procedure with fewer and less severe complications.

- Utilize all available images and prepare treatment by schematic drawing prior to beginning.
- Use landmarks (vertebral bodies) for orientation and their relation to the stone.
- Initiate lithotripsy at the side towards the kidney, as this is the largest boundary surface between stone and urine (Figs. 2.8, 2.9, 2.10e). Penetration of urine into the stone results in further enlargement, which optimises the efficacy of the shock wave energy and, thus, fragmentation.

- Treatment of hard or impacted stones or of stones persisting for extended periods of time must be initiated with high energy levels. As soon as the length of the stone has changed, therapy can be continued with lower energy levels. If the first 200 shock waves lead to visible changes of the stone, therapy is continued with the same energy level.
- In case of readjustment of the stone into the focus do not forget to readjust in the z-axis (30° fluoroscopy).
- Adjustment of energy levels is based on disintegration results. If the first 200 shock waves do not lead to visible results, energy levels must be increased instantly.
- Active treatment: continuous observation of fragment situation in order to prevent untargeted shock waves in cases of stone/fragment dislocation.

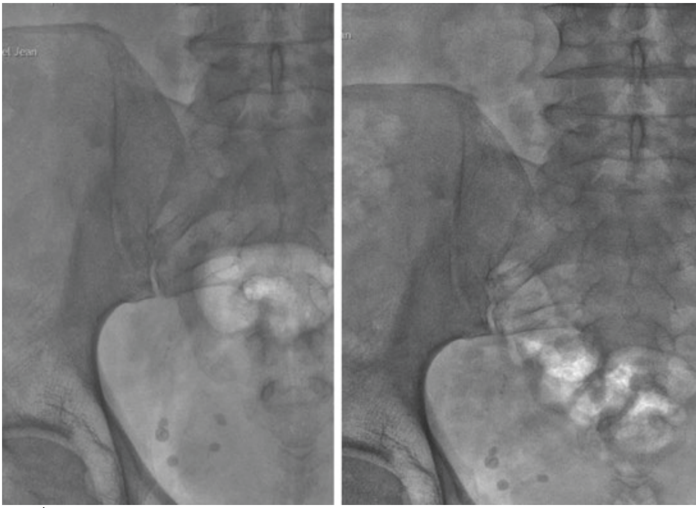
Therapeutic procedure

Stone ureter midlevel	
Energy level	**Shock waves**
7.5	600
8.5	1600

Good visualization in prone position

Disintegration with high energy levels

Results



1st day after SWL (supine position) 3 months after SWL

Comments

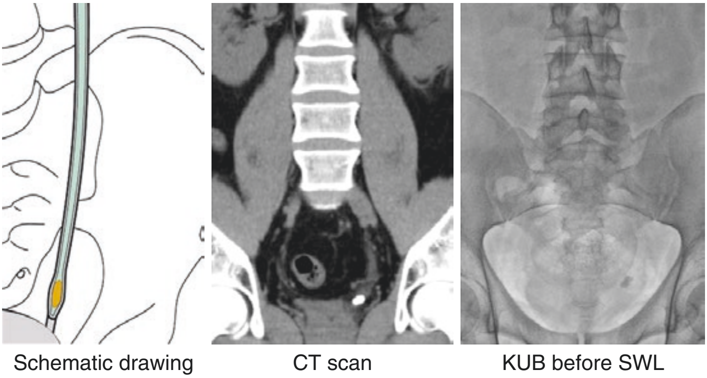
Key to successful disintegration were good intraoperative orientation and initiation with high energy levels with rapid increase up to 8.5.

Ureteral Stone Distal

Patient history

28-year-old male with symptomatic left sided distal ureteral stone (10 × 5 × 4 mm, 900 HU).

Starting position



Individual strategy

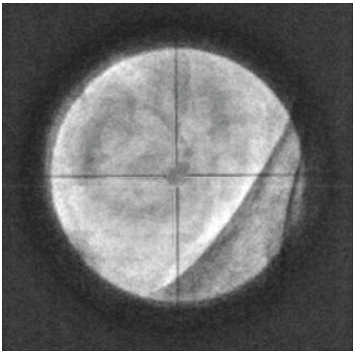
Due to stone size and location SWL in supine/prone position and URS were considered as treatment options. The patient has a history of recurrent urethral strictures, therefore stone treatment using SWL in supine position was preferred.

- Careful patient positioning: consider risk of stone migration during treatment into the bone window (Fig. 2.8a): prevesical stones can usually be treated in supine position (Fig. 2.8b). Stones located close to the sacrum or covered by bony structures should be treated in prone position (Fig. 2.8c). However, using positioning devices (e.g. wedges) may allow treatment in supine position (Fig. 2.8d).

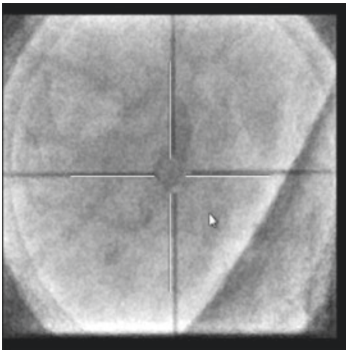
- Initiate lithotripsy at the side facing towards kidney (Fig. 2.8b, d), as this is the largest boundary surface between stone and urine (red area Fig. 2.8d). Penetration of urine into the stone results in further enlargement, which optimises the efficacy of the shock wave energy and, thus, fragmentation.
- During breathing movements the focus must always target the upper third of the stone. Excessive breathing movements (volumes >500 mL) result in shock waves outside the focus and optimisation is required, e.g. by adjusting respiratory volumes (intubated patients) or by pain reduction (patients with peridural/local anaesthesia).
- Adjustment of energy levels is based on disintegration results. If the first 200 shock waves do not lead to visible results, energy levels must be increased instantly.
- Active treatment: continuous observation of fragment situation in order to prevent untargeted shock waves in cases of stone/fragment dislocation.

Therapeutic procedure

Stone distal ureter	
Energy level	**Shock waves**
6.5	200
7.5	400
8	400
8.5	1000
9	800

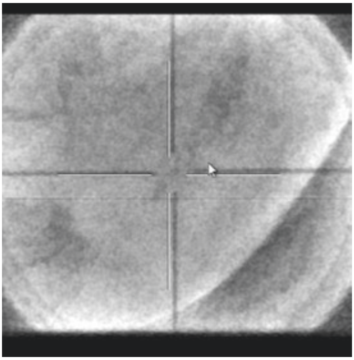


Good visualization in prone position



Disintegration with high energy levels

Results



1st day after SWL (spine position)

3 months after SWL

Comments

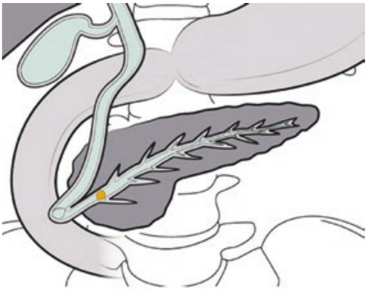
Key to successful disintegration were initiation with high energy levels and rapid increase up to 8.5.

Pancreatic Duct Stones

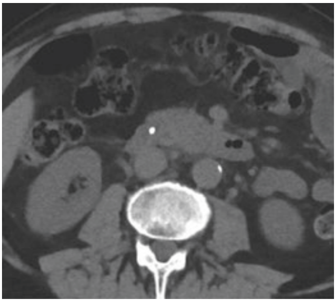
Patient history

71-year-old male with chronic pancreatitis due to an anomaly of the pancreatic duct and a 5 mm stone close to the major duodenal papilla.

Starting position



Schematic drawing



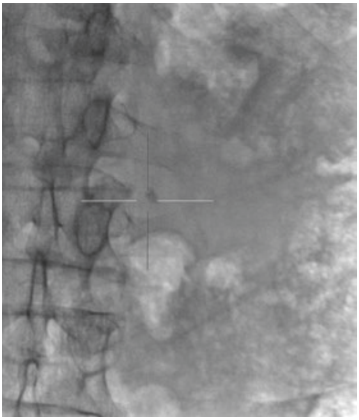
CT scan

Individual strategy

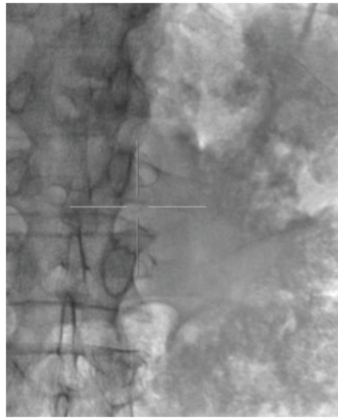
- Trial detection allows for assessment of stone visualisation before anaesthesia.
- Therapy must be conducted in prone position.
- Antibiotics should be administered before therapy.

Therapeutic procedure

Stone pancreatic duct	
Energy level	**Shock waves**
3.5	200
4.5	400
5.5	400
6	500

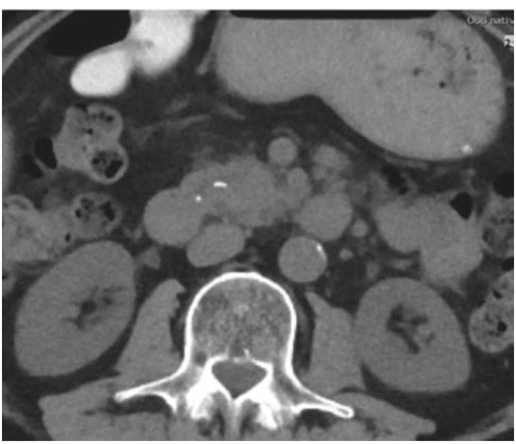


Visualization in prone position



Disintegration with high energy levels

Results



Steinstrasse 1st day after lithotripsy

Comments

No postinterventional pancreatitis was observed. Endosonography and endoscopic retrograde cholangiopancreaticography (ERCP) 3 months later revealed no residual fragments.

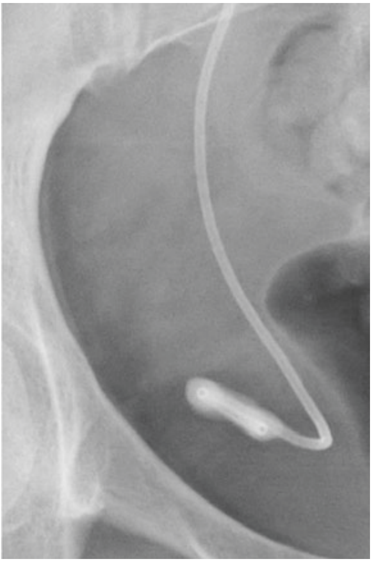
Incrustrated Double-J Stent

Patient history

22-year-old female with forgotten double-j stent inserted for symptomatic ureteral obstruction during pregnancy. Nine months later the patient complained about intermittent flank pain. KUB revealed incrustation covering the full length of the double-j stent with pronunciation at the two loops.

Starting position

Incrustation covering the full length



Pronounced incrustation at the loop

Individual strategy

- Begin of SWL in general anaesthesia at the proximal loop of the double-j stent followed by the complete length of the ureteral part. Following SWL, the double-j stent was removed using a flexible cystoscope. The consecutive retrograde ureteropyelography did not reveal any ureteral damage.

Therapeutic procedure

Incrustrated DJ	
Energy level	**Shock waves**
6.5	600
7.0	600
7.5	800

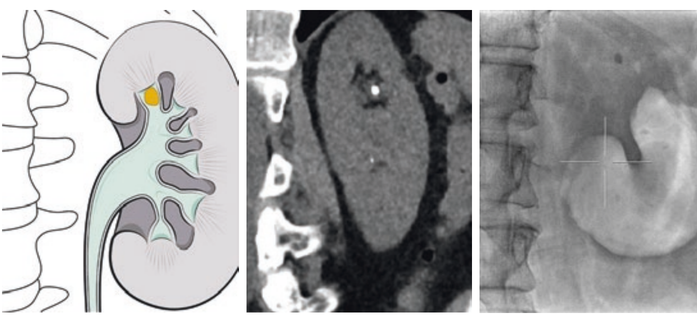
Comments

Another double-j stent was placed and finally removed 2 weeks after SWL.

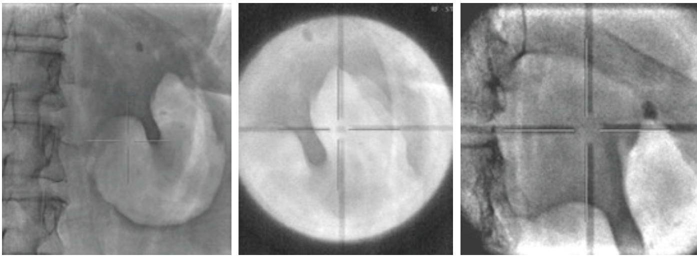
Tips for Stone Targeting

One key for successful SWL is a permanent and reliable orientation before and during the procedure. Especially in cases with impaired visibility, e.g. due to intestinal gas or during treatment of multiple smaller stones, the use of radiographic landmarks and SWL-coordinates for x-, y- and z-axis is of importance. X-rays including both, the targeted stone and bony structures, are helpful. These images should be taken before swinging in the generator. Be aware that coupling of the generator will lead to a displacement of the targeted structure. Using the previously taken panoramic X-rays including bony landmarks will allow for safe readjustment and precise targeting. Centering each stone and writing down the x-, y- and z-coordinates before coupling the generator is a useful trick to relocate the initial treatment area.

Successful stone targeting using bony landmarks



Schematic drawing | CT scan | KUB before SWL (overview)



KUB before SWL (overview) | Fluoroscopy with generator | Readjustment using bony landmarks

Appendix

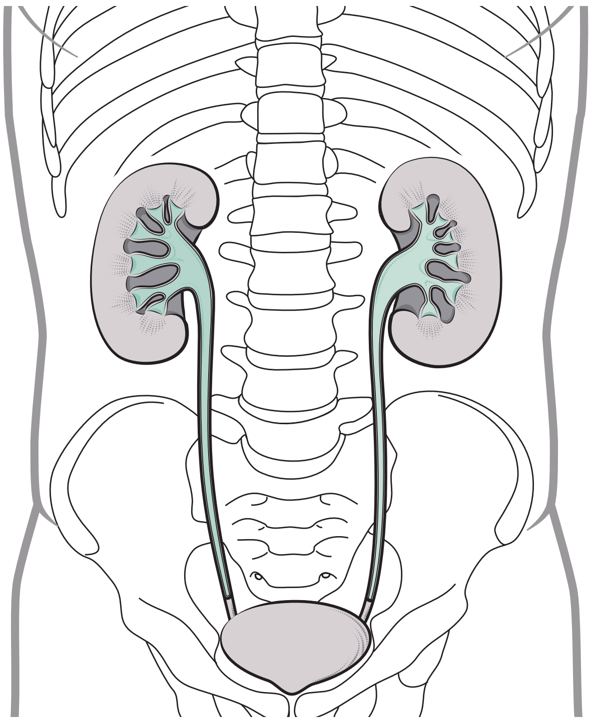


FIGURE A1 Blank schematic drawing

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In Clinical Practice, https://doi.org/10.1007/978-3-319-77640-8

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