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The radiolucent ureteric calculus at the end of a contrast-medium column: where to focus the shock waves

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Objective To compare the outcome of two different targeting strategies for treating radiolucent ureteric calculi by extracorporeal shock wave lithotripsy (ESWL), focusing the shock waves either at the end or 5 mm beyond the column of contrast medium visible in the ureter.

Patients and methods A total of 156 patients undergoing ESWL for a radiolucent ureteric stone were randomized into two groups. Group 1 comprised 74 patients in whom the shock waves were focused on the end of the contrast medium column, and group 2 comprised 82 patients in whom the shock waves were focused 5 mm beyond the end of the column.

Results Both groups had comparable distributions of age, gender, treatment methods and stone characteristics. There were no adverse reactions to the contrast medium. The stone-free rate after 2 months was 17% greater in group 2 (91%) than in group 1 (74%; $P < 0.05$).

Conclusions The administration of intravenous contrast medium for ESWL of radiolucent ureteric calculi is effective and safe. We recommend that the shock waves are focused 5 mm beyond the end of the column of contrast medium, except where a stone becomes clearly visible within the column.

Keywords extracorporeal shock wave lithotripsy, ureteric stones, radiolucent, contrast medium

Introduction

Radiolucent ureteric stones can be treated effectively with ESWL, using contrast medium to locate the obstruction [1]. With major obstruction, the stone would usually be expected to be apparent just below the end of the ureteric column of contrast medium. However, several factors may mislead the clinician when following this assumption. With total obstruction and a high-pressure calyceal system, the contrast medium might be excreted and consequently reach the stone only after a considerable delay. More importantly, with partial but nearly complete obstruction, a small amount of medium might pass beyond the stone, thus no longer delineating the end of the column; the stone will then be within the column. Contrast medium might be absorbed in some stones, giving the same effect [2]. With the new generation of lithotripters with a high-energy/small-focus configuration, the accurate targeting of the stone is essential, particularly if the stone is not visible and the practitioner has to rely on the indirect indications given by the ureteric column of contrast medium.

Thus the aim of this study was to compare the outcome of two different targeting strategies for ESWL of radiolucent ureteric stones, directing the shock waves at the end or 5 mm beyond the end of the contrast medium column.

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Patients and methods

Between March 1998 and December 1999, a total of 1974 stones were treated in the lithotripter unit of the Academic Hospital Rotterdam; 884 (45%) were ureteric and 156 of these were radiolucent. These 156 patients were assessed for the present study; all were treated as outpatients, under light sedation and analgesia.

We have no specific policy for acute ESWL; the stones were diagnosed in the outpatient clinic and considered too large to pass spontaneously (Table 1). Patients were asked to sieve their urine until the day of treatment and to bring any stones passed. The mean waiting time for ESWL was 2.6 weeks. Immediately before treatment the patient was assessed by ultrasonography for persistent renal dilatation and an MSU taken to assess microhaematuria. Patients were asked about their symptoms and stone passage. With this approach the likelihood of a spontaneous and unnoticed stone passage was decreased, and therefore any unnecessary ESWL minimized. An anaesthesiologist was always present during ESWL.

In all patients the stone could not be located with certainty and the operator relied on indirect

Table 1 The demographic details of the patients, the location and size of the stones, stone composition, complications, re-treatments and auxiliary measures, and the parameters of ESWL. None of the differences were significant

Variable	*Group 1*	*Group 2*
No of patients	74	82
Mean age, years	44.3	45.1
Men (%)	39 (52)	46 (56)
Stone characteristics		
Mean size, mm^2	29	31
right ureter, %	37	40
proximal, %	39	43
middle, %	22	19
distal, %	39	38
Stone composition, %		
Calcium oxalate	0	0
Calcium phosphate	3	4
Uric acid	41	45
Struvite	7	5
Cystine	45	42
Others	4	4
Complications, re-treatments and auxiliary measures, %		
general	0	0
contrast medium	0	0
Repeat ESWL	5	2
JJ stent	4	2
Ureterorenoscopy	3	1
Percutaneous nephrolithotomy	3	1
ESWL parameters (means)		
No. of shock waves	5678	5368
Shock wave energy, kV	15.1	15.5

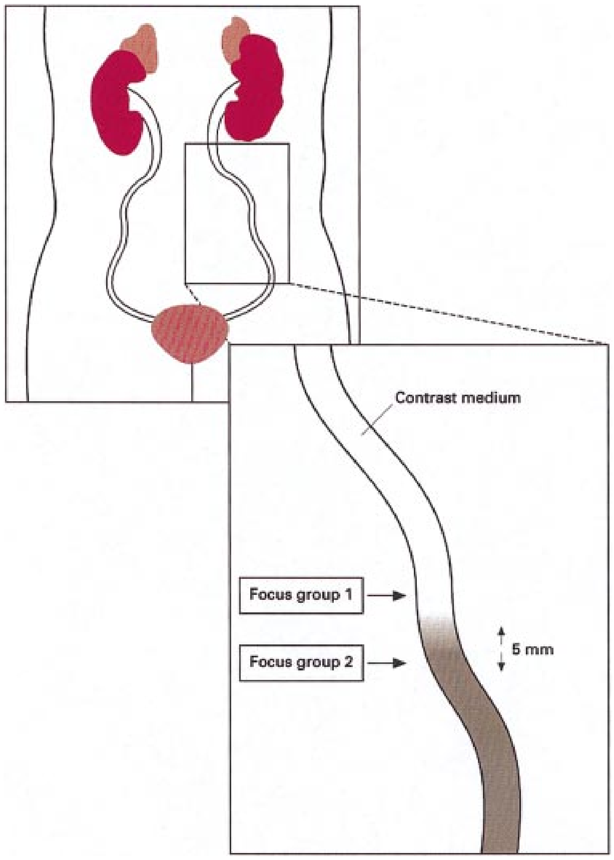

Fig. 1. The focal points at and beyond the end of the contrast medium column.

visualization, obtained by a drip infusion of 150 mL of contrast medium, administered in the 5 min before ESWL. In all patients the contrast medium was excreted at a sufficient density to allow the ureter and stone to be located. In 35 patients there was some delay until the view was clear ($\leqslant$35 min). All patients were then treated on the Lithostar Multiline® (Siemens, Germany) under fluoroscopic monitoring. The limits of ESWL were a maximum of 8000 shock waves per treatment and a maximum energy of 20 kV. All treatments were undertaken by one operator (M.vR.) to exclude operator bias.

The patients were randomized into two groups: in group 1 (74 patients) the shock waves were focused directly on the end of the contrast medium column and in group 2 (82 patients) the shock waves were focused 5 mm below the end of the column (Fig. 1). There were slightly fewer patients in group 1, largely because some did not attend their follow-up appointments.

During the follow-up the patients were assessed clinically with a plain abdominal film and/or ultrasonography, IVU if there was doubt, and urine analysis at 1 and 2 months after treatment. Patients were also asked to sieve their urine and bring any passed fragments; these were routinely analysed by X-ray spectrography. For these radiolucent stones, initial ultrasonography was used to detect the resolution of any pre-existing renal dilatation. If there was any doubt or if there was no renal dilatation before treatment, brief IVU was used to confirm the success of ESWL.

The results from the two groups were compared using Student's *t*-test, with $P < 0.05$ considered to indicate a statistically significant difference.

Results

Both groups had comparable distributions of gender and age (Table 1); there were no statistically significant differences in stone side, size, level and composition (Table 1). There were no complications other than fragment-induced colic and renal obstruction, which required slightly more auxiliary measures and re-treatments in group 1. However, these differences were not statistically significant (Table 1). The mean number and energy of the shock waves applied was not significantly different in the two groups (Table 1). The stone-free rate after 1 month was 54% in group 1 and

78% in group 2; after 2 months the rates were 74% and 91%, respectively, and the difference was statistically significant.

Discussion

ESWL is the first-line treatment for most ureteric calculi; indeed, published results are encouraging, with stone-free rates of 79–93% [3–6]. The reported rates are lower for the mid-ureter [3,5,6] and high in the proximal ureter [3,6,7]. Other factors influencing success rate are stone size, stone composition [5,8,9] and impaction [3,10]. Obesity of the patient can seriously hamper the clinical outcome, as the depth of a stone within the surrounding tissue can affect its localizability under ESWL [11].

Locating the stone becomes particularly difficult if it is radiolucent; even if the lithotripter is equipped with ultrasonography there are usually anatomical and technical limitations making localization in the ureter very difficult, if not impossible. However, in the very proximal or very distal ureter this approach might be useful. Others have proposed pushing proximal calculi back into the renal pelvis using retrograde endoscopic manipulation. Stones in the renal pelvis are usually more accessible to ultrasonographic localization and ultrasound-guided ESWL. This approach may be helpful but is invasive and therefore controversial [7,12]. There remains a considerable perioperative risk associated with this procedure. The same is true for placing a 'pointer' stent next to the stone [13], or undertaking routine retrograde ureterography [14]. The easiest method for locating the stone (although not free of risk) is the administration of a drip infusion of intravenous contrast medium. After a few minutes the column of medium appears proximal to the obstruction and can indicate the position of the stone, which appears either as a narrowing of the ureteric calibre, or more simply as the end of the column. Despite known adverse reactions, the administration of intravenous contrast medium is regarded as safe. The medium does not affect renal function, even in patients with total obstruction [15]. To further decrease the risk of adverse reactions a bolus injection can be given, rather than a drip infusion. This requires less medium and gives more rapid opacification, and consequently a shorter treatment time [1]. However, in our centre the anaesthetists advised administering the contrast medium slowly by drip infusion, to enable them to recognize any adverse reaction in the early stages, before the whole dose had been administered. There were no adverse reactions in any of the 156 patients. The advantage of the current noninvasive approach, compared with the endoscopic methods noted, outweighs the relatively minor risk attached. Nonetheless, some risk remains and thus (besides pain management) an anaesthetist attended on stand-by in each case.

Once the contrast medium column is apparent, only rarely will the stone be surrounded by medium and appear as a dark spot within the column. For most stones the ESWL operator can only see the stone indirectly, as a narrowing or clear end of the column. Thus the stone can be expected either at the end of the column or just below it. Usually the operator decides in each patient whether to target the end of the column or just beyond it, possibly depending on personal experience and inclination. The present study is the first objective assessment of the best targeting strategy for radiolucent stones that are not clearly visible within a column of contrast medium. The patients were comparable with those reported by others [3–8,10,16]; the results showed a clear and statistically significant advantage, with a 17% greater stone-free rate for patients in group 2. However, 74% of patients in group 1 also became stone-free within 2 months; considering that the present lithotripter had a relatively small focus of 5×9 mm, many stones must have been partially engulfed by the contrast medium, or had absorbed it.

Admittedly, respiratory movements in the longitudinal axis might also have partially annulled the disadvantage of the small focus, but this would have led to overlaps in both groups and thus cancelled the effect. In any case, the focus of the machine is routinely targeted in the phase between inspiration and expiration, thus minimizing the breathing error.

As a tertiary referral centre we treat many patients with cystine stones (Table 1); thus we have an extensive experience with these stones and usually try to treat most of them with ESWL, initially set at the highest permissible intensity. Such stones are hard and shock-wave resistant, but as ureteric stones can be exposed to more shock waves and at a higher intensity than can kidney stones, the cystine stones were treated successfully in most cases.

In conclusion, the administration of intravenous contrast medium for targeting radiolucent ureteric calculi during ESWL is easy, noninvasive and safe. Adverse reactions are rare, but caution is mandatory. When the column of contrast medium appears proximal to the stone we recommend focusing 5 mm beyond the end of the column except when the stone is clearly visible within the column.

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