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ORIGINAL PAPER

Urgent shock wave lithotripsy as first-line treatment for ureteral stones: a meta-analysis of 570 patients

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Abstract The rationale for the use of immediate shock wave lithotripsy (SWL) after a renal colic episode is to obtain maximum stone clearance in the shortest possible time with associated early detection of lithotripsy failures which can be treated with auxiliary procedures. The aim of this meta-analysis is to understand the role of this treatment option in the emergency setting as first-line treatment and to compare such an immediate procedure to a delayed one in terms of stone-free and complication rates. A bibliographic search covering the period from January 1995 to September 2010 was conducted in PubMed, MEDLINE and EMBASE. Database searches yielded 48 references. This analysis is based on the seven studies that fulfilled the predefined inclusion criteria. A total of 570 participants were included. The number of participants in each survey ranged from 16 to 200 (mean 81.42). Six studies were published after 2000 and one in the 1990s. All studies reported participants' age with mean of 40.9 years, and range between 11 and 88 years. All patients presented with unilateral lithiasis, as such the number of total stones treated was 570. Mean stone diameter ranged between 6.38 and 8.45 mm. According to the logistic regression applied stone-free rates were 79 % (61–95) for the proximal ureter, 78 % (69–88) for the mid ureter, 79 % (74–84) for the distal ureter and 78 % (75–82) for overall. Stone-free rates do not evidence a statistically significant difference compared to those described in the AUA and EAU guidelines for elective management. SWL management of ureteral stones in an emergency setting is completely lacking in the international guidelines and they results disperse in the literature in few works. According to our meta-analysis, immediate SWL for a stone-induced acute renal colic seems to be a safe treatment with high success rate. This evidence will be validated by further randomized studies, with a larger series of patients.

Keywords Urgent · Emergency · Shock wave · Lithotripsy · Ureteral stone · Ureter · Stone · Renal colic · Hydronephrosis

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Introduction

Renal colic accounts for about 1 % of all Emergency Department visits and 1 % of hospital admissions. It is estimated that as much as 5 % of the population will be

affected by urinary stones during their lifetime. In approximately 95 % of patients, renal colic is caused by stone disease. This is of great importance for the general public health given that the lifetime risk of urolithiasis is estimated to be between 5 and 12 % in Europe and in the USA and that about 50 % of patients will have a recurrence of renal colic within 5 years of their first episode [1, 2].

In the emergency department, the goal of renal colic treatment, in the absence of indications for immediate intervention, is symptomatic relief. In these patients, treatment options include expectant management with medical expulsive therapy. Passage of ureteral stent or positioning a nephrostomy tube, extracorporeal shock wave lithotripsy (SWL) or ureteroscopy with intracorporeal lithotripsy are reserved for uncontrolled pain, inadequate renal function, and clinical evidence of sepsis or perinephric urine extravasation [3].

With the introduction of SWL in the early 1980s as a management option for urinary stones, it has become a primary treatment for most patients with uncomplicated upper urinary tract stones. This was recently highlighted in the jointly published European Association of Urology (EUA)/American Urological Association (AUA) guidelines on ureteric stones [4]. The rationale for use of immediate SWL after a renal colic episode is to attain maximum stone clearance rate in the shortest possible time with early detection of lithotripsy failures which could be treated with auxiliary procedures.

Very few randomized studies have addressed the role of urgent SWL in the treatment of these patients who present with renal colic [5–11].

The aim of this meta-analysis is to understand the role of this treatment option in the emergency setting as first-line treatment and to compare such immediate procedure to a delayed one in terms of stone-free and complication rates.

Materials and methods

Clinical outcomes of interest were stone-free rate, number and type of complications.

Evidence acquisition

Search strategy

Studies were identified by searching electronic databases and scanning reference lists of articles. A bibliographic search covering the period from January 1995 to September 2010 was conducted in PubMed, MEDLINE and EMBASE. Additional hand searches of the reference lists of included studies, reviews, meta-analyses and guidelines on SWL in an emergency setting. The following search terms were used in each case: lithiasis, ureter, ureteral lithiasis, SWL, emergency and urgency. The searches were restricted to publications in English.

Study selection

Studies were excluded if they were case reports, meeting abstracts and conference proceedings. Identified studies were reviewed and selected if they reported the outcome of extracorporeal SWL performed as first immediate treatment in an emergency setting. Inclusion or exclusion of studies was performed hierarchically based first on the title of the report, then on the abstract, and finally on the contents of the full text. A study was accepted for inclusion on the basis of agreement of two investigators (SCMP and CR); any disagreement on study inclusion was resolved by consulting a third investigator (LC).

Database searches yielded 48 references. Exclusion of irrelevant references left 10 references describing studies. We excluded two further references because they were not in English and one for containing redundant data. This analysis is based on the seven remaining studies that fulfilled the predefined inclusion criteria [5–11]. Study selection is resumed in Fig. 1.

Data extraction and assessment of quality

One author (SCMP) extracted the following data from included studies and entered them into the data extraction form. A second author (CR) checked the extracted data to ensure data quality. Disagreements were resolved by discussion between the two review authors; if no agreement could be reached, it was planned that a third author (LC) would decide. The quality of studies was scored using the methods of the US Preventive Services Task Force. PRISMA guidelines were applied in drawing this manuscript [12].

Statistical analysis

Fixed effect logistic regression analysis was used to compare distal, proximal and mid stone-free rates. Relative risk and 95 % confidence limits for all comparison were performed (Fig. 2). To investigate for heterogeneity the I^2 test was applied. The comparison between emergency stone-free rates and AUA-EUA guidelines results was performed by means of percentage comparison using a fixed effect logistic model. Pooled, pooled expected stone-free rates and 95 % confidence limits were compared with AUA-EUA results and reported in Fig. 3. Finally, to investigate to what extent stone diameter influenced stone-free rates a random effect logistic meta-regression analysis having the

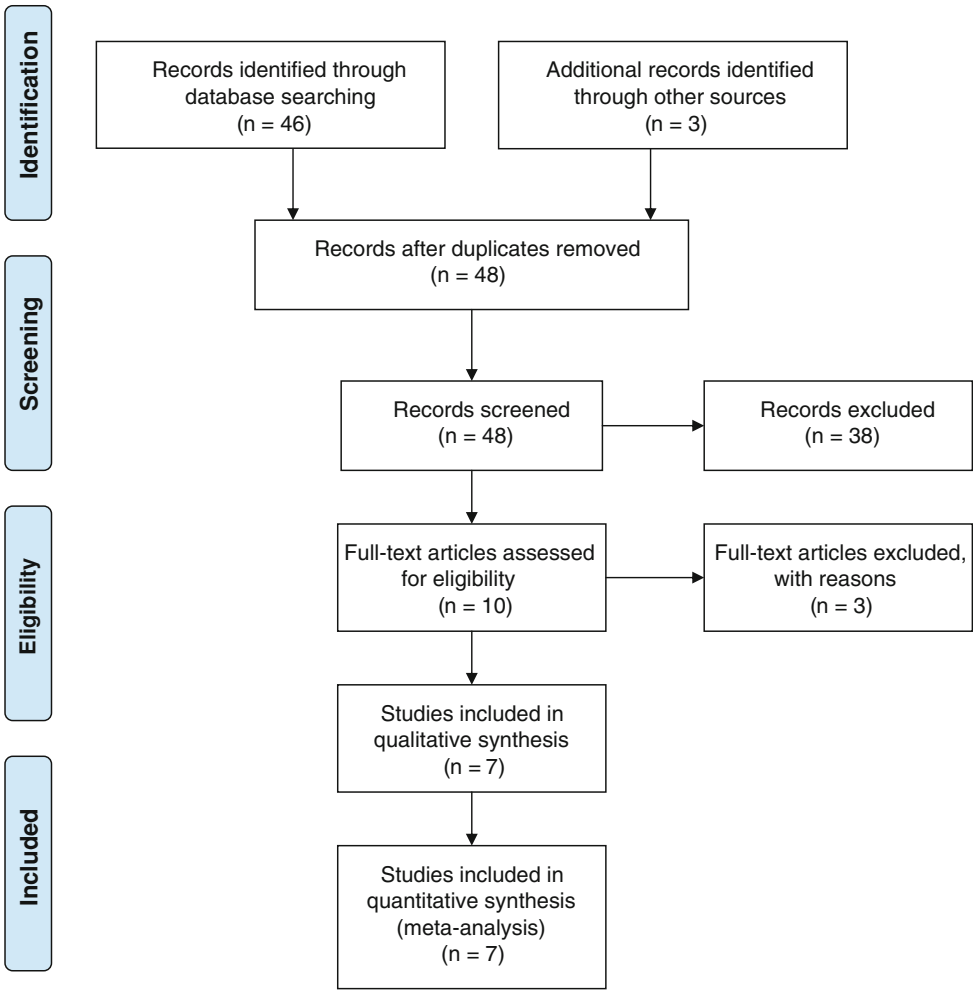

Fig. 1 PRISMA 2009 flow diagram shows the selection process

overall stone-free rate (sum over distal, mid and proximal ureters) as response variable and medium stone diameter as covariate was applied. All logistic models were accommodated for overdispersion by Williams or Pearson deviance criterion as adequate [13, 14]. Statistical evaluations were performed by SAS statistical software package 9.2 and by Revman 5 version 5.0.24.

Results

Analysis of the database

Table 1 summarizes all the included studies regarding the use of SWL in an emergency setting as first-line treatment and Table 2 reports all the inclusion and exclusion criteria and types of lithotripter used [5–11]. A total of 570 participants were included in the 7 studies examined in this meta-analysis. The number of participants in each survey ranged from 16 to 200 (mean 81.42). Six studies were published after 2000 and one in the 1990s.

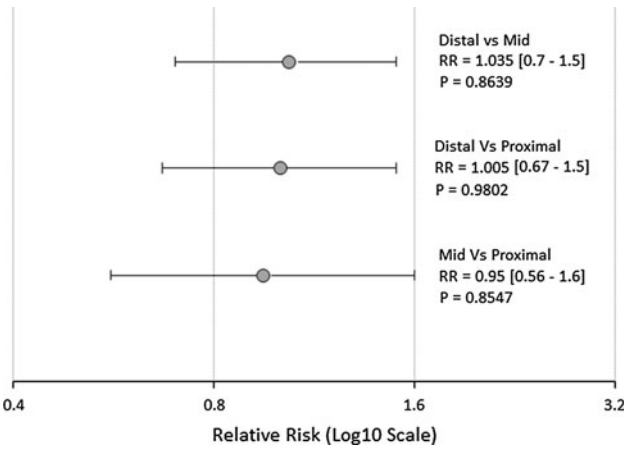

Fig. 2 Relative risk and 95 % confidence limits of the comparison between distal, mid and proximal ureter stone-free rates

Austria, Belgium, France, India, Israel, Jordan and UK provided one study each. Enrollment starts from 1994 and ends in 2009. The time interval in which patients were recruited in different studies varies between 1 and 6 years.

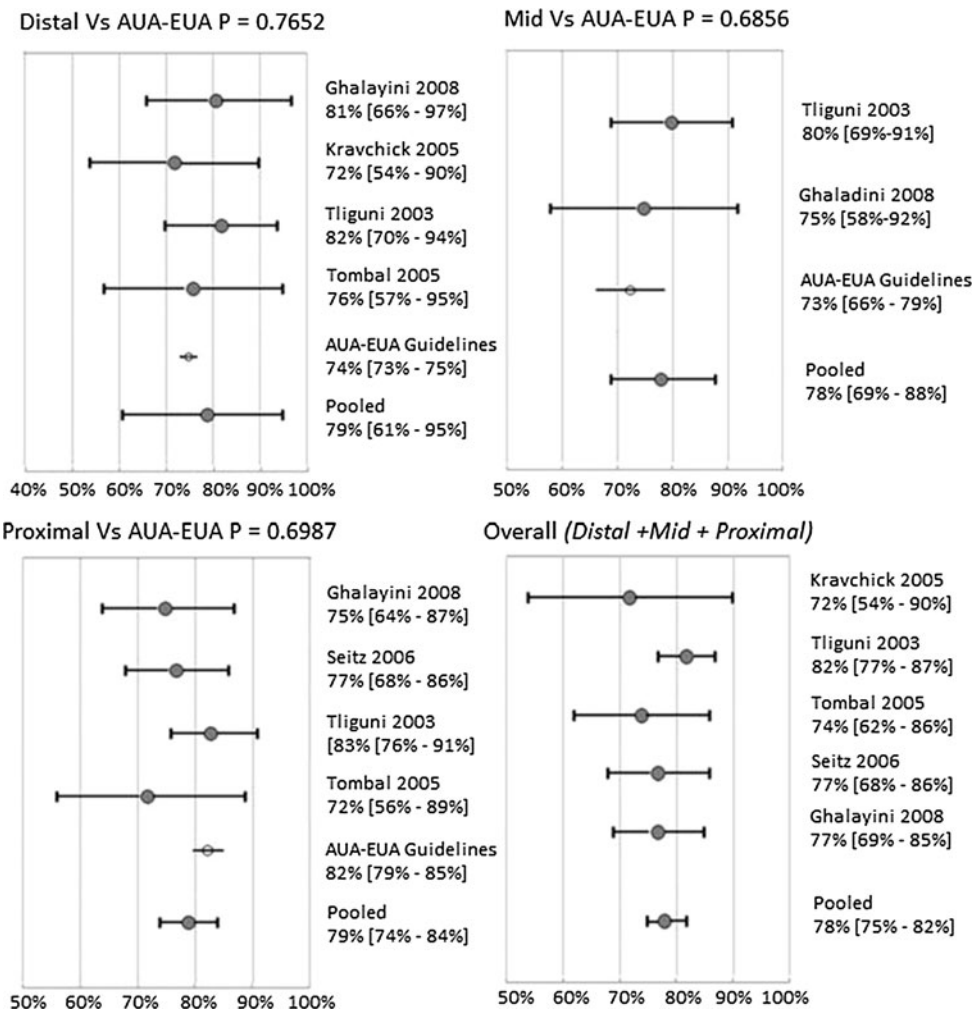

Fig. 3 Pooled expected stone-free rates and 95 % confidence limits of the comparison between distal, mid and proximal ureter stone-free rates to the AUA-EUA guidelines

Database was divided into the following section:

- general information about the study population including: the authors, publication year, nationality of the study, interval of time in how the subjects were enrolled, total number of patients, gender, age (range and mean age);
- inclusion and exclusion criteria, presence of unilateral or bilateral ureteral lithiasis, stone diameter, stone location in the proximal, mid and distal ureter;
- number of procedure, successful procedure, post-operatory and late stone-free rate, number and type of complication, stone migration rate, post-procedural stenting (double and single J stents) use and time to removal, the need of auxiliary surgical intervention (ureteroscopy, open uretero-lithotomy or percutaneous lithotripsy).

Patients' characteristics

Six studies reported patients' gender. Males were 265 and females were 214 with a ratio of 6:5. All studies reported participants' age with a mean of 40.9 years and range between 11 and 88 years. All patients presented with unilateral lithiasis, so the number of total stone treated was 570. Mean stone diameter ranges between 6.38 and 8.45 mm.

Overall analysis of the outcomes on stone-free rate

Stone-free rates were 79 % (61–95) for proximal ureter, 78 % (69–88) for mid ureter, 79 % (74–84) for distal ureter and 78 % (75–82) for overall according to logistic regression applied.

There were no differences among distal, proximal and mid stone-free rates as reported in Fig. 2. Stone-free rates reported by distal, mid and proximal ureters were homogeneous among the included surveys (I^2 test for heterogeneity $P > 0.10$). All of the pooled stone-free rates did not result statistically significant when compared to those described for this type of procedure performed in an elective fashion in the AUA and EAU guidelines.

Table 1 Summarizes all the included studies regarding the use of SWL in an emergency setting as first-line treatment

References	Nation	Enrollment time	Patients (tot)	Male (n)	Female (n)	Age (years)	Range (years)	Stone diameter (mm)	Range (mm)	Overall stones free rate (%)	Stones distal ureter (n)	Stone-free rate (%)	Stones mid ureter (n)	Stone-free rate (%)	Stones proximal ureter (n)	Stone-free rate (%)
Kravchick [7]	Israel	1999–2003	25	9	16	45.2	25–65	7.4	5–12	72	25	72	0	nr	0	nr
Kumar et al. [11]	India	2008–2009	80	44	36	37.4	nr	7.3	nr	86.3	nr	nr	nr	nr	nr	nr
Joshi et al. [5]	UK	1994–1997	16	12	4	54.3	29–88	8.2	6.5–8.2	81	6	nr	3	nr	7	nr
Tligui et al. [6]	France	1994–2000	200	75	125	42	20–83	7.2	3–20	82	44	81.8	54	79.6	102	83.3
Tombal et al. [8]	Belgium	2001–2003	50	40	10	44	nr	6.38	2–10	74	21	76.2	0	nr	29	72.4
Seitz et al. [9]	Austria	2003–2005	91	nr	nr	45.9	24–81	7.9	3–15	76.9	0	nr	0	nr	91	76.9
Ghalayini et al. [10]	Jordan	2002–2007	108	85	23	39.5	11–72	8.45	4–20	77	27	81.5	28	75	53	75.5

nr not reported

The relation between stone-free rates and stone diameters was not statistically significant having a slope estimate of −0.05, a standard error of 0.18 and a P value of 0.7682.

Complications

Complications were divided into fever, infection and sepsis, haematuria, perinephric haematoma, and stainstrasse. They were not reported in all the studies. When described, they accounted for 9.9, 0.6, 22.3, 0.5 and 4.1 %, respectively.

Subsequent surgical procedure

In eighteen patients (3.6 %), the drainage of the upper urinary tract was necessary. In particular, a ureteral stent was placed in 11 and a nephrostomy tube in 7.

Surgery after the SWL treatment was necessary in 90 cases (15.8 %) to complete stone removal. Of all the studies which describe the subsequent surgical intervention, 72 consisted of ureteroscopy and two of percutaneous nephro-lithotripsy.

Discussion

Most ureteral stones can be observed with a reasonable expectation of uneventful stone passage; this strategy, if successful, is generally less costly and less invasive than all other possible options [15]. International guidelines today recommend active removal of all stones exceeding 5–7 mm, when proven that they have resisted medical therapy. Active removal is also strongly indicated in patients with persistent pain despite adequate medical treatment, acute obstruction with impaired renal function or solitary functional kidney, urinary tract infection and risk or suspicion of urosepsis. In cases where removal of ureteral stone is warranted, the main debate currently gravitates between the choice of SWL or endoscopic management combined with laser or mechanic fragmentation [10].

Conclusions on the SWL management of ureteral stones in an emergency setting are completely lacking in the international guidelines and they results disperse in the literature in few works. Although extracorporeal SWL is widely considered as one of the treatments of choice for ureteral stones in the emergency setting; however, there still appear to be limited data on its effectiveness compared with the well-documented advances in medical expulsive therapy or ureteroscopy.

The goal of ureteral calculi management is to achieve fast, complete stone clearance with minimal morbidity. In a meta-analysis, we recently reported that the use of medical

Table 2 Studies of inclusion and exclusion criteria and types of lithotripter used

References	Inclusion criteria	Exclusion criteria	
Ghalayini et al. [10]	Acute renal colic that proved to be resistant to anti-inflammatory agents or that recurred within 24 h of such treatment	Pregnancy, urinary tract infection, coagulation disorders or previous ureteral reimplantation, presence of a perirenal urinoma, temperature >38 °C, blood leukocytes >20,000/dL, solitary kidney, radiolucent stones, or prior history of ureteral stricture or tumor, serum creatinine >1.8 mg/dL, stone located in the renal pelvis or the pyelo-ureteral junction	Dornier lithotripter S (MedTech Europe GmbH, Germany)
Joshi et al. [5]	Delayed visualization and dilatation of the pelvicalyceal system and ureter above the level of the stone, with no contrast medium beyond the stone in the ureter or a persistent and dense nephrogram with nonvisualization of the collecting system	nr	Siemens Lithostar Multiline (Siemens GmBh, Germany)
Kravchick et al. [7]	Acute renal colic, radiopaque 5-mm to 1.5-cm calculus in the uretero-pelvic junction or upper ureter	Coagulation disorders, pregnancy, evidence of urinary tract infection or acute renal failure	Econolith electrohydraulic lithotripter
Kumar et al. [11]	Radiopaque upper ureteral stone <1 cm, who presented with an episode of colicky pain	Bleeding disorders, active urinary infection, age >60 and <15 years, weight >100 and <40 kg, comorbid cardiovascular and respiratory illnesses, fever >38.8 °C, total leukocyte count >12,000 dL^{-1}, serum creatinine level >1.5 mg/dL, solitary kidney, coexisting ureteral pathology including tumor/stricture, pregnancy, and severe hydronephrosis	Electromagnetic lithotripter (Dornier Alpha Compact)
Seitz et al. [9]	At least one episode of acute renal colic, and no previous active treatment	Pregnant women, ureteric strictures, clotting disorders, solitary non-functioning kidney and fever	Piezolith 3000 (Richard Wolf, Knittlingen, Germany)
Tligui et al. [6]	Acute renal colic that proved to be resistant to anti-inflammatory agents or that recurred within 24 h of such treatment	Urine infection, blood coagulation disorders, pregnancy and heart deficiency	EDAP LT-02 piezo-electric lithotriptor
Tombal et al. [8]	Acute flank pain caused by ureteral stone, patient requiring intravenous administration of drug and fluid either because of the onset of nausea and/or vomiting or pain persisting despite correct use of oral drug, and radiolucent stone clearly identify on play X-ray allowing ESWL	Stone >10 mm in largest diameter, dilatation of the renal pelvis >30 mm or presence of a perirenal urinoma, rectal temperature >38.8 °C, blood leukocytes >20,000 dL^{-1}, serum creatinine >1.8 mg/dL, urine leukocytes >25/field, stone located in the renal pelvis or the pyelo-ureteral junction, solitary kidney, prior history of ureteral stricture or tumour	Siemens Lithostar Multiline (electromagnetic)

nr not reported

expulsive therapy associated with analgesics, antispasmodic agents (tamsulosine and nifedipine), anti-inflammatory drugs, adequate hydration, and antibiotics gives the patient the chance to spontaneously pass the stone [16]. We demonstrated that medical expulsive therapy could be proposed as a treatment for patients with ureteral calculi who are amenable to a waiting management. Benefits associated with medical expulsive therapy are a shorter time to spontaneous stone expulsion and less need for analgesic drugs and hospitalization for treatment. Also, according to another of our meta-analysis, immediate ureteroscopy for stone-induced acute renal colic appears to be a safe treatment with high success rate even if this evidence needs to be validated by further randomized studies on larger series of patients with investigation of the economic benefits of emergency ureteroscopy in terms of diminished drug administration, less need for clinical surveillance, and earlier return to work and daily activities [17]. However, the stone diameter seems to affect stone-free rate in patients treated with urgent ureteroscopy as first-line therapy. Every 1 mm diameter increase greater than 8 mm corresponds to a 5 % (2.4–8.0) and an 8.1 % (3.8–12.1) reduction of the stone-free rate for distal and proximal ureters, respectively [17].

Ever since its introduction, extracorporeal SWL has become an effective treatment for urinary tract stones. The efficacy of SWL and its low morbidity rate make it a desirable option in the management of ureteral stones, even during acute renal colic secondary to ureteral stone obstruction. The success rate of SWL in the treatment of

ureteral stones is about 80 %. The European/American Urological Association (EAU-AUA) ureteral stones clinical guidelines evidence stone-free rates of 82 % in the proximal ureter, 73 % in mid ureter and 74 % in distal ureter [4]. The management outcome of ureteral stones depends on many factors such as location, stone size, composition, degree of obstruction and presence of complications whilst other factors affect stone disintegration such as surface-to-stone distance, degree of obstruction/impaction of stone in ureter, type of lithotripter, focusing mechanism, pulse rate and power used.

The pathophysiology which supports early use of SWL in these patients is that ureteral edema (which develops gradually after 24–48 h) caused by an impacted symptomatic calculus impairs stone clearance. This ureteral edema also prevents the formation of the expansion chamber and liquid interface, thus also reducing fragmentation rates after SWL.

The available data regarding SWL in the emergency setting suggest that this is a safe procedure, with an overall success rate that did not result statistically significant when compared to those described to the delayed one in the AUA and EAU guidelines. The 'failure rate' reported in most of these studies relates to the need for further intervention following early SWL (e.g. ureteroscopy or stent insertion) and is of the order of 20 %. It is therefore important to acknowledge the rate of complications such as fever, infection/sepsis, perinephric hematoma, and stainstrasse which vary between 0.5 and 9.9 % and which do not differ from those reported in the more recent international guidelines [3].

The fact that the surveys chosen were from different years and different countries, representing different medical systems and equipment is a merit of this meta-analysis. This allows us to define more widely the effectiveness or ineffectiveness of a procedure that we evaluate.

Conclusions

According to our meta-analysis, immediate treatment for ureteral stone seems to be a safe treatment with good success rate. In the emergency setting the use of SWL appears less invasive with respect to ureteroscopy, without the need of anesthesia and its associated complications. It is slightly more aggressive with respect to medical expulsive therapy but expensive for stone smaller than 8 mm. These evidences need to be validated by further randomized studies on larger series of patients.

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