Surgical management of bladder stones: literature review

Tratamento cirúrgico da litíase vesical: revisão de literatura

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A B S T R A C T

Bladder stones are rare and in most cases occur in adult men with bladder outlet obstruction. Currently, there are few data on the best treatment of this disease. The aim of this review is to discuss some aspects of pathogenesis and treatment approaches for bladder lithiasis. A comprehensive search of the database of the "National Library of Medicine" / pubmed was conducted with the following key words and descriptors: "bladder" or "vesical" associated with "calculus", "stone" or "lithiasis", and "cystolithotripsy ". One hundred and seventy-one articles were identified. The articles were independently assessed by two reviewers with expertise in urolithiasis. They were included in the study when the results, complications and follow-up were clearly reported. In the end, 32 studies met the inclusion criteria. Several options for the treatment of bladder lithiasis are available, but no randomized trials comparing them. Different rates of calculus-free patients are described in each of them, as follows: extracorporeal shock wave lithotripsy (75-100%), transurethral cystolithotripsy (63-100%), percutaneous cystolithotripsy (89-100%) and open surgery (100 %). The percutaneous approach has lower morbidity, with similar results to the transurethral treatment, while extracorporeal lithotripsy has the lowest rate of elimination of calculi and is reserved for patients at high surgical risk.

Key words: Lithiasis. Urinary bladder calculi. Urolithiasis. Therapeutics. Lithotripsy.

INTRODUCTION

Urinary lithiasis affects about 5% of the Western population [1]. The calculi are formed of calcium in 70% of cases, of uric acid in 20%, of magnesium ammonium phosphate (struvite) in 10% and of cystine and less than 1% [2]. Urine is a stable solution and any variation in the degree of saturation, of the urinary pH and of the concentration of crystallization inhibitors can alter the existing equilibrium and result in urolithiasis [3].

Bladder stones are rare in developed countries and in adults they are most commonly associated with bladder outlet obstruction, chronic infection or the presence of an intravesical foreign body [4]. They can occur in childhood and are related to malnutrition, especially in a protein-poor diet [5]. Regarding the clinical presentation, bladder stones may be asymptomatic. However, symptoms such as suprapubic pain, dysuria, hematuria, weak and choppy urine stream, hesitancy, frequency, urgency and pain in the glans may occur in over 50% of patients [6,7].

Currently, there is a paucity of data regarding the best approach for bladder calculi. The aim of this study was to report some aspects of pathogenesis and mainly discuss the treatment of bladder lithiasis.

METHODS

We conducted an extensive research in the database of the "National Library of Medicine" / Pubmed. The following keywords were investigated: "vesical" or "bladder" associated with "calculus", "stone" or "lithiasis", and "cystolithotripsy". Other papers were identified from the references of the articles found. The publication date was not an exclusion criterion. One hundred and seventy-one articles were identified. Only the English language and human studies were reviewed. Two reviewers with expertise in urolithiasis independently assessed a total of 67 articles. These were included when the results, complications and follow-up were clearly reported. In the end, 32 studies met the inclusion criteria (Figure 1). As there are no randomized studies available, most of the comments of this review were based on case series or comparative cohort studies. We sought to conduct a critical analysis of current data available regarding the management of bladder lithiasis.

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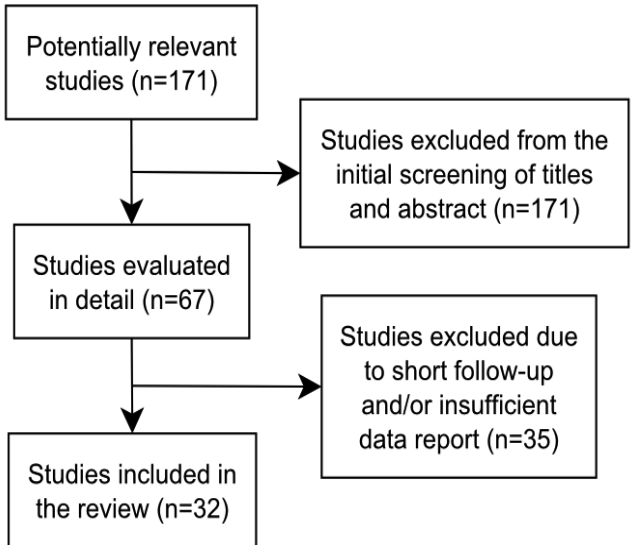

Figure 1 - *Process of inclusion of studies in the review.*

Pathogenesis of bladder stones

A. Adults

Outlet obstruction is the main etiological factor in over 75% of cases of bladder lithiasis [8], which provides stasis and infection, change in urinary pH, urine supersaturation and heterogeneous nucleation, with calculus formation. This condition usually affects men over 50 years, the benign prostatic hyperplasia (BPH) being the most common cause, followed by urethral stricture and adenocarcinoma of the prostate. These calculi are made of uric acid, calcium oxalate or magnesium ammonium phosphate (struvite). The latter is associated with infection by bacteria "breakers" of urea. Generally, the calculi are unique, but they may be multiple in 25-30% of cases [9].

Urinary tract infection can be associated with the pathogenesis of bladder lithiasis in 22-34% of cases, and *Proteus sp*. is the most commonly isolated microorganism from urine cultures [8]. *Proteus* and some strains of *Pseudomonas* and *E. coli* produce urease, which hydrolyzes urea, resulting in ammonia and carbon dioxide, raising the pH and promoting urinary supersaturation and precipitation of crystals of magnesium ammonium phosphate [9].

B. Children

Nutritional deficiency of vitamin A, magnesium, phosphate and vitamin B6, associated with low intake of protein and a carbohydrate-rich diet are implicated in the pathogenesis of pediatric bladder lithiasis [6]. Furthermore, dehydration, diarrhea, fever and infection may reduce urine output and increase crystallization [6]. These conditions acidify the urine and contribute to the formation of bladder stones [5]. The children endemic vesical lithiasis is commonly associated with uric acid stones, isolated or associated with calcium oxalate. Nonetheless, calcium phosphate may be present [10].

Treatment

A. Adult

In the treatment of bladder lithiasis, one must consider the size and composition of the calculus, the comorbidities of the patient, the presence of previous surgery and anatomic abnormalities of the lower urinary tract, costs, as well as equipment available. The elimination of the causal factor is mandatory for therapeutic success [7].

Extracorporeal shock wave lithotripsy (ESWL) is an, with the benefit of being a noninvasive procedure [11]. However, it does treat the etiology and may not promote the elimination of all fragments of the stone. The efficacy is associated with the calculi size and the best results are obtained when they are smaller than 2 cm [11]. Thus, ESWL is the standard treatment for most adults with urolithiasis and is considered a good option for patients with small calculi and high surgical risk.

We proceed to reported ESWL studies in the treatment of urinary lithiasis. Since there are no prospective studies, the best evidence to date is based on retrospective ones. Bhatia *et al*. [11], in a series of 18 patients with urinary lithiasis, obtained complete fragmentation in 77.7% and 99.9% of cases after one and two rounds of ESWL, respectively. Husain et al. [12] described the use of ESWL in the treatment of bladder stones larger than 2.0 cm (average size 3.5 cm) in 24 cases. All underwent endoscopic evacuation of the fragments immediately after ESWL, thus obtaining 83% of patients free of calculi. Delaskas *et al*. [13] treated 52 patients with ESWL and obtained complete fragmentation in 88.4% of cases after one session, and increase of 5.7% after a second session. A cystoscopy was necessary to evacuate the calculi in 17% of patients. Kostakopoulos *et al*. [14] reported 72% of patients free from calculi after ESWL in a series of 36 cases. Garcia Cardoso *et al*. [15] performed ESWL in 45 patients and, after one to five sessions, 99.4% of patients were free of lithiasis, 13% of patients requiring cystoscopy assistance. Kojima *et al*. [16] reported less than satisfactory results in the treatment of urinary calculus in 17 men with ESWL. They had complete fragmentation in nine cases (52%) with a single session and four additional cases (23%) with two sessions. Trapeznikova et al. [17] described a series of 52 patients with BPH and bladder stones who underwent ESWL prior to transurethral resection of the prostate (TURP). After one to three ESWL sessions, complete or partial fragmentation of the calculi was obtained in all cases, shortening and facilitating the subsequent endoscopic procedure (Table 1).

The development of thinner and easier to use endourologic instruments has made the transurethral and percutaneous procedures extremely attractive to urologists and patients. The endourologic classical approach in the treatment of urinary lithiasis is based on the fragmentation

and removal of the calculi through the urethra. Fragmentation is obtained from sources of mechanical/ballistic, ultrasonic, electro-hydraulic or laser energies. Several studies have demonstrated the superiority of the holmium: YAG laser compared to other lithotripsy methods [14-19]. Un-in *et al.* [18] compared 23 patients undergoing lithotripsy with holmium: YAG laser with ten patients treated with ballistic lithotrispy. All patients were free of calculi, but the use of the holmium laser procedures provided faster and more effective treatments for large calculi. Teichman *et al.* [19] reported their experience in treating stones larger than 4.0 cm with holmium laser in 14 patients. The mean duration of anesthesia was 57 minutes, all patients were free of calculi and were discharged on the first postoperative day. Shah *et al.* [20] described their experience with simultaneous TURP and endoscopic cystolithotripsy with holmium laser. Thirty-two men with bladder calculus of average size of 3.5 cm and an average of 52 grams prostate underwent the combined procedure. All were free of calculi, the average hospital stay was 35.8 hours and the authors conclude that this may be the treatment of choice for patients with BPH and bladder calculus. Kara *et al.* [21] reported the use of transurethral holmium laser in cystolithotripsy under local anesthesia in 13 patients with bladder calculus greater than 3.0 cm (average size 3.6 cm), obtaining 100% of patients free of calculus, mean operative time of 51 minutes and mean hospital stay of 2.3 days. At 17 months follow-up, there were no cases of urinary retention or urethral stenosis. Razvi *et al.* [22] compared the effectiveness of mechanical, ultrasonic and electro-hydraulic lithotripsy in a group of 106 patients with bladder calculus. According to the authors, all the methods were effective, but ultrasound was better for larger and harder calculi. The success rate was 88%, 63% and 90% for the ultrasonic, electro-hydraulic and mechanical methods, respectively. Nevertheless, the complication rate was higher with mechanical lithotripsy (9%) than with ultrasonic (none) or electro-hydraulic (6%) ones. Again, the best available evidence comes from retrospective studies.

Another topic of interest in transurethral surgery is the diameter of the sheath (device) used in surgery, especially in men due to the risk of urethral stricture. [23] Sathaye described the transurethral use of a nephroscope (24 Fr sheath) in four patients (three males and one female) for the treatment of bladder stones greater than 10 cm. All patients were free of calculi and there were no complications in this small series, the authors concluding that this is an effective and low morbidity method. Ener *et al.* [24] compared the use of transurethral cystoscope (16 Fr) to nephroscope (24 Fr) in a group of 43 patients. Patients were divided into two groups: 22 patients (group 1) underwent cystolithotripsy with the nephroscope and 21 patients (group 2) were operated with the cystoscope. In group 1, the operative time was shorter (48 x 68 min., P <0.01) and during the three-month follow-up there was no urethral stricture. The authors concluded that for large bladder stones the nephroscope is effective and makes the procedure faster, stating that a longer follow-up is required to confirm the safety of the procedure.

The introduction of percutaneous techniques has increased the therapeutic arsenal of bladder stones. The procedure consists in the calculus approach by a suprapubic puncture, thus avoiding urethral trauma. Small series with good results have been recently reported. As in studies with ESWL and transurethral cystolithotripsy, there are no prospective studies describing the results of the percutaneous approach. Ikari *et al.* [25] reported 89% success rate in 36 patients treated with percutaneous ultrasonic cystolithotripsy. Wollin et al. [26] reported 100% success rate and no complications in 15 patients treated percutaneously. Demeriel *et al.* [27] reported the results in percutaneous cystolithotripsy using pneumatic lithotrispy in a group of 72 patients with neurogenic bladder dysfunction (42 adults and 30 children). Calculi had an average size of 5.5 cm in adults and 3.2 cm in children. The mean operative time was 20 minutes, all patients were free of calculi and there were no major intra- or postoperative complications. Tzortzis *et al.* [28] published the results of the percutaneous treatment of bladder stones under local anesthesia. Thirty-one patients underwent surgery, with success of 96.7%, with fever and hematuria observed in patients one and five, respectively. Sofer *et al.* [29] reported the combined use of the percutaneous and transurethral approaches in giant bladder stones. In this procedure, two urologists worked

Table 1 - Extracorporeal Shock Wave Lithotripsy (ESWL).

Author	Year	Number of patients	Number of sessions	Success rate	Evidence level
Bathia et al. [11]	1993	18	2	99.90%	4
Husian et al. [12]	1994	24	1	83.00%	2c
Delaskas et al. [13]	1998	52	2	94.10%	2c
Kostakolopoulos et al. [14]	1996	36	1	72.00%	2c
Garcia Cardoso et al. [15]	2003	45	5	99.40%	2c
Kojima et al. [16]	1998	17	2	75.00%	4
Trapeznikova et al. [17]*	2001	52	3	100%	2c

** Transurethral resection of the prostate and evacuation of calculi were performed after ESWL in all cases.*

simultaneously, one on each access. The main advantage of this technique is a reduction in surgical time. Twelve patients with calculi average size of 6.0 cm were successfully treated, mean operative time of 56 minutes and mean hospital stay of 2.7 days. The authors concluded that the combined access can shorten operative time, being safe in the treatment of large calculi. Table 2 summarizes the results of the endourologic approach in the treatment of bladder stones.

Comparative studies between different therapeutic modalities are scarce. Bhatia *et al.* [30] treated 128 patients with bladder calculi, five with open surgery, 80 endoscopically and 43 with ESWL. Open surgery was 100% effective in the removal of bladder stones, however demanding average hospital stay of 5.2 days. The endoscopic lithotripsy had the highest complication rate (25%), including bladder perforation, bleeding and urethral stenosis, and mean hospital stay of 2.4 days. ESWL was the one with a shorter hospital stay, with an average of 20 hours, though four (9%) of the patients required repeated sessions for complete fragmentation the calculus.

Tugcu *et al.* [31] compared cystolithotripsy to transurethral percutaneous approach in patients undergoing TURP with bladder calculus. Thirty-two patients were treated by transurethral resection, while 25 were approached percutaneously. Mean operative time was significantly longer in the transurethral access, three (7%) of such patients having residual calculi and requiring a second approach, and other three (7%) developing urethral stricture at follow-up. The authors concluded that the percutaneous approach is safer, faster and more effective. Aron *et al.* [32] conducted a similar study comparing the transurethral access to the percutaneous one for bladder stones larger than 3 cm. Nineteen patients underwent transurethral cystolithotripsy, and 35, percutaneous. In both groups, TURP was performed simultaneously. The operative time was again higher in the transurethral access, and three patients had residual calculus and one developed urethral stricture. The authors concluded, again, that the percutaneous approach was safer, faster and more effective.

B. Children

Open surgery was considered the gold standard treatment of bladder lithiasis in pediatric patients for a long time, offering excellent success rates [6]. Abarchi *et al.* [33] obtained 100% of patients free of calculi in a series of 70 children with bladder stones.

The development of smaller equipments, associated with increased experience of endourologists with minimally invasive procedures, has led to more endoscopic approaches to bladder stones in pediatric patients. If in adults there are no good prospective studies, in children the situation is no different. Ramakrishnan *et al.* [34] described their experience with transurethral holmium laser in infants using an 8 Fr ureteroscope. Twenty-three patients with stones smaller than 4 cm (average size 2.7 cm) were treated with 100% success, without major complications and without recurrence in mean follow-up of 42 months. Salah *et al.* [35] percutaneously approached 155 children younger than 14 years old with calculi measuring between 0.7 and 4.0 cm (mean 2.3 cm). All patients were free of calculi without major complications, with mean operative time of 20 minutes (5-60 minutes) and mean hospital stay was 2.7 days (2-5 days). Gan *et al.* [36] reported their experience with children less than one year of age. Fifteen boys with a mean age of 8.2 months (3.0 to 11.5 months) and average calculi of 1.4 cm (0.9 to 2.2 cm) were treated percutaneously. All children were free of calculi, with

Table 2 - Endourologic cystolithotripsy.

Author	Year	Access	Number of patients	Power Source / lithotrispy	Success rate	Evidence level
Un-no *et al.*[18]	2000	Transurethral	33	Holmium: YAG laser or ballistic	100%	2b
Teichman *et al.*[19]	1997	Transurethral	14	Holmium:YAG laser	100%	4
Shah *el al.*[20]	2007	Transurethral	32	Holmium:YAG laser	100%	2c
Kara *et al.*[21]	2009	Transurethral	13	Holmium:YAG laser	100%	4
Razvi *et al.*[22]	1996	Transurethral	106	Ballistic or electro-hydraulic or ultrasonic	90% ballistic, 63% electro-hydraulic, 88% ultrasonic	2b
Sathaye *et al.*[23]	2003	Transurethral	4	Holmium:YAG laser	100%	4
Ener *at al.*[24]	2009	Transurethral	43	Ultrasonic-pneumatic	100%	2c
Ikari *et al.*[25]	1993	Percutaneous	36	Ultrasonic	89%	2c
Wollin *et al.*[26]	1999	Percutaneous	15	Pneumatic	100%	4
Demeriel *et al.*[27]	2006	Percutaneous	72	Pneumatic	100%	2c
Tzortzis *et al.*[28]	2006	Percutaneous	31	Pneumatic and ultrasonic	96,7%	2c
Sofer *et al.*[29]	2004	Transurethral e Percutaneous	12	Pneumatic and ultrasonic and / or laser and / or ultrasonic	100%	4

average operating time of 25 minutes and mean hospital stay of 2.8 days. Al-Marhoon *et al.* [37] compared endourologic procedures with open cystolithotomy in children with an average age of five (2-15 years) and bladder calculus of average size 2.8 cm (0.7 to 5.0 cm). Fifty-three patients were treated by open cystolithotomy and 54 patients by transurethral or percutaneous access. All patients were free of calculi and the operative time was similar between the groups. The hospital stay was significantly lower in children submitted to the endourologic approach (2.6 vs. 4.8 days, p <.05). Moreover, early and late complications occurred only in children treated by endourologic access, with four cases of urinary fistula and one urethral stricture. The authors concluded that although the length of stay is higher with open surgery, it is safer.

In the management of pediatric bladder lithiasis, prevention cannot be forgotten. In endemic areas it is very important to perform a feeding re-education, increasing the consumption of phosphorus, protein, vitamins and magnesium. A balanced diet, removing excess carbohydrate and increasing the protein content, combined with a good hydration, can contribute to reduction of urinary lithiasis in most children [6].

Calculuns in urinary reservoirs

Calculi in patients with urinary diversion represent a challenge to urologists, due to the presence of significant anatomical changes. It is mandatory for the surgeon to be aware of the type of derivation and of the continence mechanism of each case [38]. In most cases, the right colon or ileum is used to set a reservoir of high volume and low pressure. Basically, the mechanisms of urinary drainage may include with Valsalva voiding through the urethra, auto-catheterization or voiding associated with defecation (ureterosigmoidostomy) [38].

Predisposing factors for stone formation in reservoirs include urinary stasis, bacteriuria and chronic mucus production 38. Kaefaer *et al.* [39] studied 207 patients with bladder augmentation or urinary diversion and reported the occurrence of calculi in 15% of the reservoirs in an average time of 3.6 years, the majority of struvite 39. Woodhouse *et al.* [40], in a retrospective study of 146 patients with enterocystoplasty, reported an incidence of 15.8% of calculi in urinary reservoirs, and the average time for their formation of 45 months. In this study, 56% of calculi were removed percutaneously and 46% (stones greater than 5 cm) by open surgery. In all cases, calculi were composed of struvite.

In patients with orthotopic urinary reservoir, the calculus size may hamper the transurethral approach, and open surgery becomes the most classical treatment. In patients with continent cutaneous derivations, where the continence mechanism is constructed with imbricated ileal segments, minor manipulations can cause incontinence or stenosis [38], the percutaneous access being then preferred [41-43].

Lesnic *et al.* [41] reported a small series with the percutaneous approach in seven patients with bladder augmentation. A 10-12mm laparoscopic trocar was used to introduction of a rigid nephroscope and fragmentation of the stones. All patients were free of calculi, with no complications. Paez *et al.* [42] percutaneously treated 12 patients with urinary diversion, obtaining 100% of patients free of calculi and without complications, with a mean follow up of 24 months. Natalin *et al.* [43] associated percutaneous dilation with a laparoscopic trocar for the treatment of urinary reservoir calculi. Five patients were successfully treated with this combined access, being free calculi during a mean follow-up of 32.4 months.

The algorithm for the treatment of bladder stones suggested by the authors is shown in figure 2.

CONCLUSION

The percutaneous approach has lower morbidity, with similar results to the transurethral treatment. The ESWL has the lowest rates of elimination of calculi and is reserved for patients at high surgical risk and calculi smaller than 2cm.

R E S U M O

Cálculos vesicais são raros e a maioria dos casos ocorre em homens adultos com obstrução infravesical. Atualmente, existem poucos dados sobre o melhor tratamento desta doença. O objetivo desta revisão foi discutir alguns aspectos da patogênese e abordar o tratamento da litíase vesical. Uma ampla pesquisa na base de dados da "National Library of Medicine"/Pubmed foi realizada com os seguintes unitermos e descritores: vesical ou bexiga associados a cálculo, pedra ou litíase, e cistolitotripsia. Cento e setenta e um artigos foram identificados. Os artigos foram avaliados independentemente por dois revisores com experiência em urolitíase. Foram incluídos quando os resultados, complicações e seguimento foram claramente reportados. No final, 32 estudos preencheram os critérios de inclusão. Nota-se que diversas opções para o tratamento da litíase vesical estão disponíveis, porém não há estudos randomizados comparando-as. Diferentes taxas de pacientes livres de cálculo são descritas, sendo: litotripsia extracorpórea com ondas de choque (75-100%), cistolitotripsia transureteroscópica (63-100%), cistolitotripsia percutânea (89-100%) e cirurgia aberta (100%). O acesso percutâneo apresenta menor morbidade com resultados semelhantes ao tratamento transuretral, enquanto a litotrispsia extracorpórea apresenta as menores de taxas de eliminação de cálculos e fica reservada aos pacientes de alto risco cirúrgico.

Descritores: *Litíase. Cálculos da bexiga urinária. Urolitíase. Terapêutica. Litotripsia.*

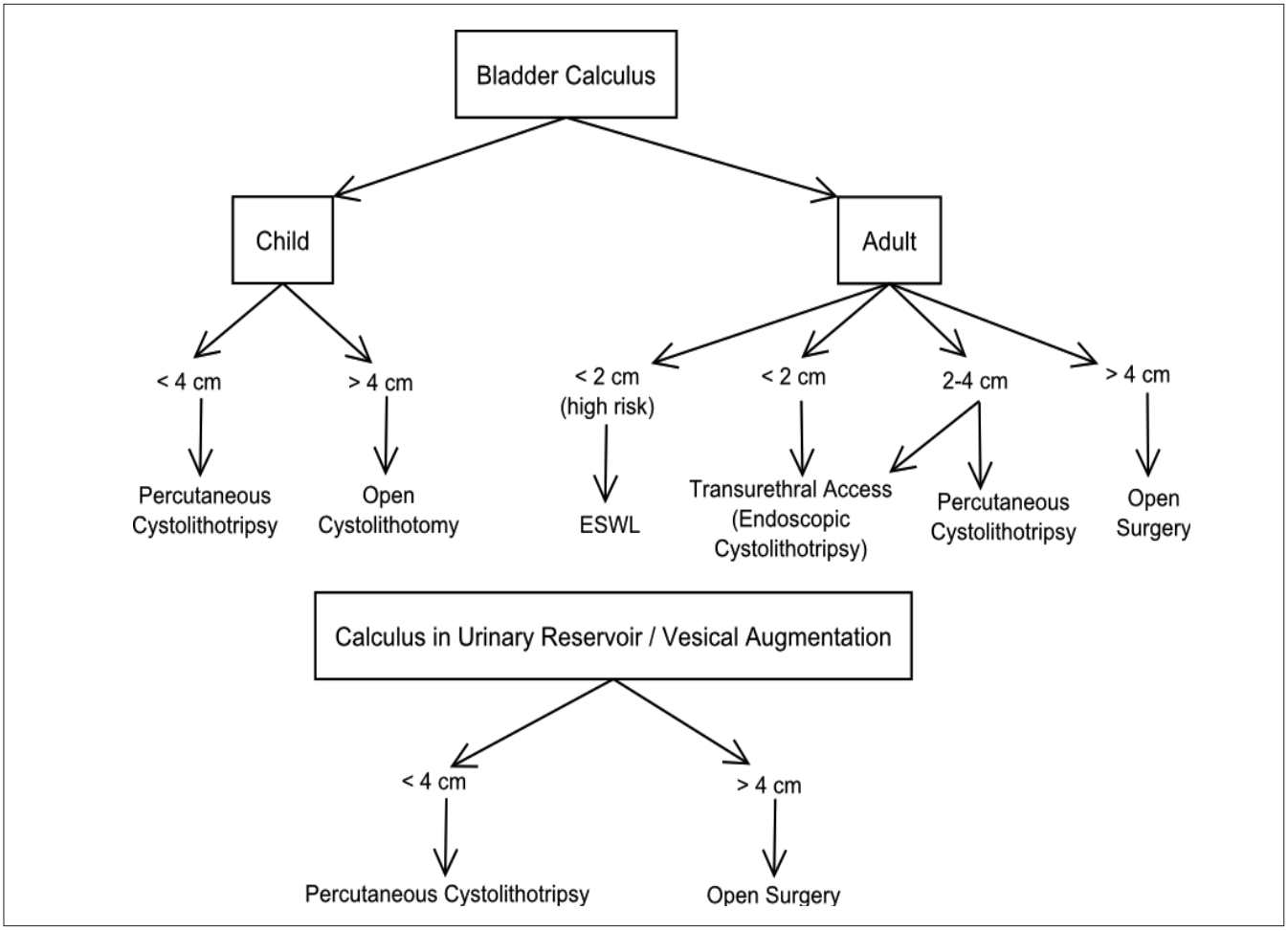

Figure 2 - *Treatment of bladder stones suggested by the authors.*

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