# Management of urolithiasis in patients after urinary diversions

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After urinary diversion patients are at increased risk of long-term complications, including stones of the upper urinary tract and reservoir or conduit. Advances in instrumentation and techniques have expanded treatment options, while minimizing morbidity. Minimally invasive treatment methods include shockwave lithotripsy, antegrade and retrograde ureteroscopic lithotripsy and percutaneous nephrolithotomy. Percutaneous and laparoscopic techniques are applicable to stones within urinary diversions. Medical management is crucial for avoiding recurrent stones in these patients.

**What's known on the subject? and What does the study add?**

Patients undergoing urinary diversion are at increased risk of stone formation in the upper urinary tract and within the pouch. Several studies have reported wide ranging outcomes of the various surgical and non-surgical management options.

In this article we reviewed risk factors, etiology, and outcomes of surgical and medical management of diversion-associated urolithiasis. A surgical management algorithm was developed based on the known literature to serve as a guide to treatment stones in these patients. The relative effectiveness of various preventive management strategies are reviewed and summarized.

KEYWORDS

urinary diversion, conduit, neobladder, ileal, nephrolithotomy, calculi

## INTRODUCTION

Advances in urinary diversion techniques have greatly improved the health-related quality of life of patients undergoing radical cystoprostatecomy. While most patients do well after surgery, various long-term complications can occur, including stomal stenosis, uretero-intestinal anastomotic stricture, chronic renal insufficiency, vitamin B12 deficiency, electrolyte abnormalities, diarrhoea, and UTIs. These patients are also at increased risk of urolithiasis, which can cause sepsis, pouch infection, pyelonephritis, renal insufficiency, haematuria and pouch perforation. This review focuses on the etiology and surgical and medical management of diversion-associated urolithiasis.

## INCIDENCE

The prevalence of urolithiasis in patients with urinary diversions varies from 3 to 43% depending upon the series. Terai *et al.* [1] from Kyoto University reported a stone formation rate of 12.9% in patients with Indiana Pouch diversions vs 43% in patients with the Kock pouch [1]. In a similar study by Arai *et al.*, 5.4% of patients with Indiana pouches and 26.5% with Kock pouches were found to have stones. A 16.7% long-term stone formation rate was noted by Ginsberg *et al.* [2] in patients with the Kock pouch. In a study by Webster *et al.* [3] there was a reservoir stone rate of 5.4% for the Florida pouch. A series of 800 patients with Mainz pouch diversions, with a median follow-up of 7.6 years, showed a 10.8% incidence of stones in reservoirs with an intussuscepted ileal nipple and 5.6% in reservoirs with an appendiceal stoma [4]. The incidence of upper tract stones in patients with urinary diversions is comparable with the general population [1,5–8].

## OVERVIEW OF RISK FACTORS

Patients with urinary diversions are at increased risk of upper tract stones as well as calculi within the diversion segment. Both continent and incontinent diversions are at risk. Factors promoting stone formation include bacterial colonization and diversion-associated urinary metabolic derangements. Other risk factors include urinary stasis, reflux of mucus into the upper tract and exposure of nonabsorbable surgical material, such as staples, to urine within the reservoir. The use of nonabsorbable materials in urinary diversions has largely been abandoned.

### BACTERIAL COLONIZATION

Most patients with urinary diversions become colonized with a multitude of bacteria regardless of the type of diversion. Colonization rates range from 14 to 96% [9–13]. Nonetheless, most of these patients ultimately remain asymptomatic, despite colonization with known uropathogens. In patients with conduits, the most common colonizers were skin flora such as *Streptococcus spp.* and *Staphylococcus epidermitis* [14]. In a study of the prevalence of asymptomatic bacteriuria in patients with continent diversions, Suriano *et al.* [11] published urine culture results from 40 patients with orthotopic ileal neobladders. Of the samples taken, 57% were positive for bacteria. The most common bacteria isolated from these cultures were *Escherichia coli, Enterococcus feacalis, Enterococcus faecium and Proteus mirabilis* [10].

Since most patients are reconstructed with refluxing uretero-intestinal anastomoses, the upper tracts often become colonized with

*FIG. 1. Pyelogram showing a matrix stone in the renal pelvis in a patient with an ileal conduit.*

urea-splitting organisms. These bacteria include *Klebsiella spp., Pseudomonas spp., Proteus spp., Providencia spp., Ureaplasma urealyticum, Staphylococcus spp., Citrobacter freundii, Streptococcus spp.,* and *Enterococcus spp.* Urease hydrolyses urea into ammonium and hydroxyl ions. This splitting of urea and water into ammonium and bicarbonate ions has a dual purpose. Firstly, it creates an abundance of ammonium ions and phosphate ions. Secondly, the bicarbonate ions serve to alkalinize the urine. These conditions allow the ready precipitation of magnesium ammonium phosphate crystals ($(NH_4)MgPO_4 \cdot 6H_2O$) and carbonate apatite crystals ($Ca_{10}$ ($PO_4$) 6•$CO_3$) in the presence of alkaline urine (pH > 7.2).

## DIVERSION-ASSOCIATED METABOLIC DERANGEMENTS

Terai *et al.* [7] evaluated the impact of urinary diversion type on metabolic stone risk factors. In their study, patients with continent urinary reservoirs, such as the Kock and Indiana pouches, were found to have long-term increases in urinary excretion of calcium, phosphate and magnesium compared with ileal conduits. It is also well known that the use of long segments of ileum can lead to enteric hyperoxaluria, thereby increasing the risk of stone formation in these patients [15].

The use of colonic or ileal segments for bladder substitution results in a hyperchloremic metabolic acidosis. The etiology of this metabolic abnormality is the ready exchange of bicarbonate and chloride ions between the urine and bowel surface. The resulting systemic acidosis causes impaired calcium reabsorption from the proximal tubules and decreased renal production of citrate. There is also an increase in citrate absorption by the bowel segments. This complex of events leads to hypercalciuria, hypocitraturia, alkaline urine, abundant ammonium and phosphate ions, each of which promotes stone formation.

Patients with continent reservoirs are at risk for chronic diarrhoea depending on the length of ileum resected. With less small bowel to absorb fluids, the capacity of the large bowel to do so is easily overwhelmed, leading to an osmotic diarrhoeal state. Patients undergoing resection of the ileocecal valve are particularly at risk. The presence of inflammatory bowel disease and previous radiation therapy are additional risk factors. Roth *et al.* [15] reported a 15% rate of chronic diarrhoea in 100 patients undergoing continent urinary diversion with ileal and ileocecal segments. They noted that patients with ileal segments 45–50 cm in length, in addition to the usual 15–20 cm of colon, were more likely to have diarrhoea unresponsive to medication. Leonard *et al.* [16] reported a 20% rate of chronic diarrhoea in their group of paediatric patients after continent reservoirs.

Bile salts are irritative to the intestines, causing a secretory diarrhoea. In the absence of adequate ileum to absorb bile salts and fatty acids, they transit into the large bowel where they undergo saponification by binding calcium. An absorptive hyperoxaluria occurs because there is less calcium available to complex with oxalate in the gut, resulting in more ionized oxalate being available for absorption. In chronic diarrhoeal states, hyperuricosuria and hyperuricaemia are also seen. In the absence of purine overindulgence, the true cause of hyperuricosuria in patients with urinary diversions is poorly characterized.

## STONE COMPOSITION

Simplistically, diversion stones may be classified as either metabolic or infectious. While most patients contain a mix of both types of calculi, the bulk of their stone burden is usually composed of magnesium ammonium phosphate (struvite). Nonetheless, calcium oxalate, carbonate apatite, hydrogen urate and calcium phosphate stones have all been reported [1]. Struvite stones are most often composed of a matrix core with matrix also being interspersed throughout the stone. The usual source of matrix is from the bowel segment (Fig. 1).

## SURGICAL MANAGEMENT

Advances in minimally invasive endoscopic techniques have shifted the surgical management of upper urinary tract stones away from the realm of open surgery. These advances have resulted in decreased hospital stays and faster recuperation. Despite the high success rates associated with these newer management techniques, the reconstructed urinary tract poses a variety of challenges. Given the unique anatomy, cross-sectional imaging with CT and other techniques are indispensible in surgical planning.

### RENAL AND URETERIC STONES

Several management options are available for upper tract urinary calculi in patients with urinary diversions (Fig. 2). The initial management for small diameter ureteric stones continues to be conservative. For patients requiring intervention, ESWL is a good initial treatment option given the potential difficulty in endoscopically accessing the ureter in patients with reconstructed urinary tracts.

In general, ureteric access is more easily achieved in ileal conduits than in reservoirs owing to the lack of an afferent limb. Regardless of diversion type, the main difficulty lies in locating the neo-ureteric orifices, which are often not clearly visualized. This also creates difficulties when attempting to gain percutaneous renal access because contrast cannot be infused into the collecting system. In these cases, ultrasound guidance becomes indispensible. With the use of ultrasonography, a small finder needle may be advanced into the collecting system and a nephrostogram can be taken to identify the best calyx for stone clearance, which can then be targeted fluoroscopically. Alternatively, blind access into the collecting system can be obtained using anatomic landmarks, but this is not recommended.

Another technical challenge in patients with urinary diversions is reduced ureteroscope deflectability. Capacious reservoirs permit proximal ureteroscope buckling. More than one area of angulation in the course of a flexible ureteroscope limits the degree of tip deflection. This is caused by a change in the deflecting cables of the ureteroscope. In these cases, small diameter laser fibres and Nitinol baskets are recommended since they interfere less with ureteroscope deflection.

Both flexible and rigid instruments are often needed to render patients stone free. This is particularly true in cases of distal ureteric stones. Stones located within the ureter near the uretero-ileal anastomosis, particularly the segment traversing under the root of the mesentery, require skill in manoeuvering the flexible ureteroscope to obtain optimal visualization for lithotripsy and stone basketing. In some cases, disintegrating the stone into tiny fragments with the laser fibre is advisable when basket extraction is not efficient.

STONES IN CONDUITS

Stones in these types of diversions most often result from foreign bodies such as staples, sutures, and stones passed from the upper tracts. Residual urine and stomal stenosis are also risk factors [17,18]. For ureteric stones in patients with loop diversions, a loopogram is useful in assessing the patency of the uretero-intestinal anastomosis. Where successful retrograde access can be achieved, use of a super-stiff guidewire and placement of a ureteric access sheath can greatly simplify repeated accessing of the ureter. The super-stiff guidewire and access sheath help to straighten out redundancies in the bowel loop during the endoscopic procedure.

STONES IN RESERVOIRS AND NEOBLADDERS

Risk factors for stone formation in continent reservoirs are directly related to residual urine, build-up of mucus, acidic urine and bacterial colonization. These factors are exacerbated by not irrigating the pouch [19,20]. Different methods have been described to manage reservoir and neobladder stones (Fig. 3). Access to stones within the reservoir can be accomplished in many ways. The simplest and least invasive is a trans-stomal approach; however, the continence mechanism in cutaneous reservoirs is often fragile, placing the patient at risk of stomal stenosis or incontinence when a trans-stomal approach is used. This approach is therefore discouraged except for very small stones requiring minimal manipulation. In most cases, the stoma should only be used as a means of filling the pouch. For orthotopic diversions, rigid and flexible instruments can be used via the urethra. The choice of lithotripters (holmium laser, mechanical or electro-hydraulic lithotripters) remains the same in these patients.

Percutaneous access is often ideal in neobladder or reservoir patients because it allows the greatest flexibility for instrumentation. Before access, preoperative imaging should be carefully reviewed to delineate the location of adjacent bowel and vascular structures that may be encountered with access and instrumentation. Ultrasound

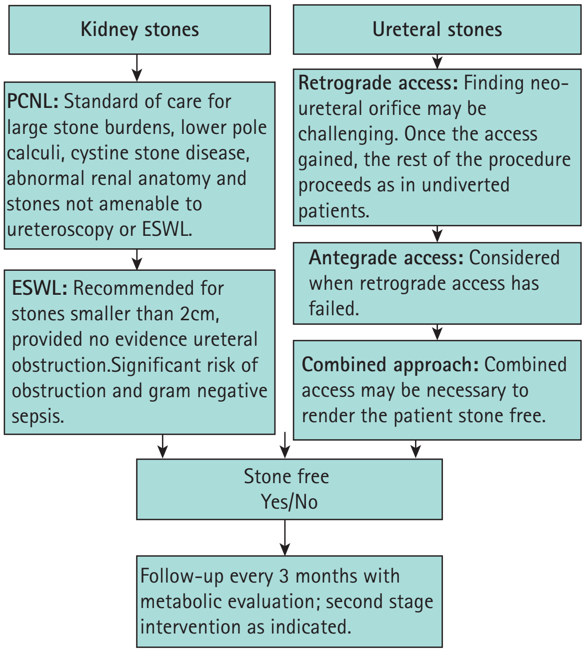



*FIG. 2.*
*Treatment algorithm for upper urinary tract stones in patients with urinary diversions. PCNL, percutaneous nephrolithotomy.*

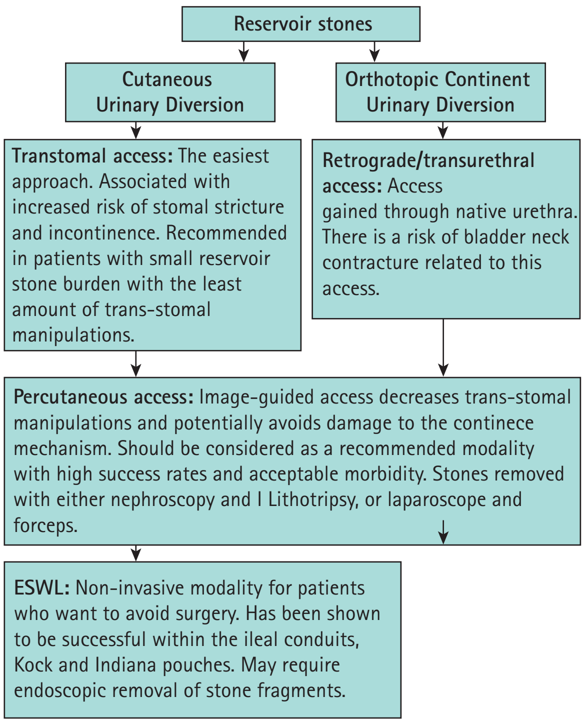



*FIG. 3.*
*Treatment algorithm for reservoir stones.*

*FIG. 4. Cystoscopy-guided transillumination access into pouch.*

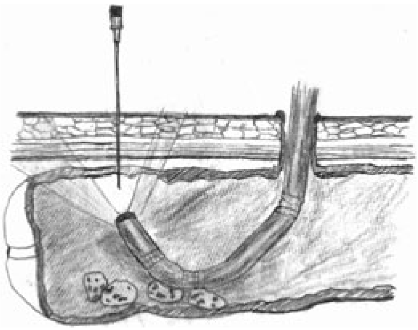
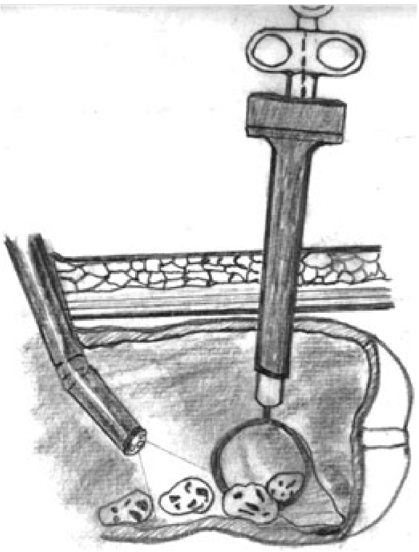


*FIG. 5. Stones placed into an endocatch bag.*



guidance is useful as adjacent bowel can be clearly determined when introducing the percutaneous finder needle. Additionally, placement of a flexible endoscope trans-stomally allows visualization of the access and dilation process. Optimal sites for access can be transilluminated by deflection of the endoscope to visualize the anterior wall of the pouch. One or two Amplatz sheaths may be placed as needed to facilitate stone removal (Fig. 4).

As an alternative, laparoscopic trocars can be used. Again, multiple trocars can be placed, allowing for separate camera and working ports as needed. To avoid damage to the intestinal mucosa, stones can be placed into a laparoscopic endocatch bag. Stone fragmentation can then proceed inside the bag, or the stone can be removed intact by widening the skin incision and removing the bag and stones together (Fig. 5) [21–28].

Fluoroscopy is a useful adjunct during these cases as it can help detect residual fragments, which often hide within mucosal folds. If intracorporeal lithotripsy is inevitable, ultrasonic lithotripters are preferable to the electro-hydraulic variety. The ultrasound waves cause far less mucosal trauma compared with electrohydraulic lithotripters [29]. Another distinct advantage of the ultrasonic lithotripter is the ability to simultaneously suction out stone fragments, making the process more efficient. Stones as large as 5 cm and multiple calculi have been treated successfully using these techniques [21,29].

Laparoscopic ureterolithotomy has been described as an alternative to open or endoscopic approaches. Advanced laparoscopic skills are required owing to the altered anatomy, and the presence of bowel adhesions, which pose a significant challenge to access and dissection. In the right hands, this technique is very successful [30–33].

## DRAINAGE AFTER STONE REMOVAL

Various options exist for pouch drainage after stone removal. These include ureteric stents, pigtail nephrostomy tubes, re-entry nephrostomy tubes, nephroureteric tubes, and Foley catheters. Ureteric stents can be used in minor cases where ureteric lithotripsy was performed. An extra long ureteric stent should be used, and if necessary, the string tether should be left attached to facilitate removal without the need for pouchoscopy. Patients undergoing percutaneous pouch access should be drained with a Foley catheter for about 7 days. The tube is then clamped and intermittent catheterization of the stoma is restarted. If there are no problems, the Foley catheter is then removed from the pouch.

For renal and antegrade lithotripsy cases, pigtail nephrostomy, nephroureteric and re-entry nephrostomy tubes are options. However, in cases with significant bleeding, a large bore nephrostomy tube is necessary [34]. For cases with significant ureteric oedema, or requiring stricture dilation, a drain traversing the compromised area should be used. This may be accomplished with either a nephroureteric tube or pigtail nephrostomy tube in combination with a ureteric stent. It is important to re-assess the questionable area for patency with an antegrade nephrostogram or retrograde pyelogram before tube removal. Alternatively, a renal scan can be used to assess the efficacy of the procedure after drain removal.

## PREVENTION OF RECURRENT STONES

Patients with urinary diversions are at high risk for recurrent stones. Recurrent stones are reported to be as high as 63% over a 5-year follow-up period by Cohen *et al.* [5].

Catheterization alone may not adequately evacuate small stone crystals and mucus within the reservoir. Both can act as a nidus for new stone formation. Several authors have investigated the impact of pouch irrigation protocols on stone formation. Hensle *et al.* [35] noted that patients on an irrigation protocol had an overall incidence of reservoir calculi of 7% vs a rate of 43% in those not irrigating their reservoirs. Terai *et al.* [1,36–38] reported a 12% lifetime risk of stone formation in Japanese patients with an Indian pouch vs 5.4% for patients in the USA. The only difference noted was that patients in the USA with Indiana pouches were routinely placed on standard pouch irrigation protocols.

It is also important to completely empty the reservoir of residual urine. Timed voiding and a catheterization schedule can go a long way towards helping to achieve this. Additionally, this may also aid in reducing the bacterial colony count within the reservoir, which is a risk factor for development of infectious stones [39,40].

Correction of the metabolic abnormalities is also critical in the management of these patients. In addition to hypovolaemia, hypocitraturia also needs to be addressed with oral supplementation in order to further decrease the risk of recurrent disease [37,41]. For patients with infectious stones, antibiotic prophylaxis may be indicated, particularly in patients with recurrent stones. In addition to antibiotic prophylaxis, acetohydroxamic acid, a potent urease inhibitor, can be used. Suby's G solution and Hemiacidrin have been used in dissolution therapy, particularly in cases where there are tiny residual fragments, which promote new stone formation. Other options for medical prophylaxis include aluminum hydroxide, which binds phosphate in the gut thereby decreasing its absorption [40,42,43].

*TABLE 1 Selected papers on the surgical management of stones*

| Author/ study | Diversion type/Configuration | No patients | Stone location | Median (range) follow- up, months | Stone type | Success rate | Notes |
|---|---|---|---|---|---|---|---|
| Breda *et al.* [44] | n/r | 74 | Reservoir: 74 | n/r | n/r | 95% | Percutaneous access under fluoroscopic guidance. 12% minor postoperative complications. Stone-free rate confirmed at 14 days with a plain abdominal film. |
| Lam *et al.* [45] | Indiana pouch: 1, bladder augmentation: 6, appendicovesicostomy: 1 | 8 | Ureters: 2 Reservoir: 6 | n/r | n/r | 100% | Removal of a large burden diversion stones with combination of laparoscopic and endourological techniques. No intra/postoperative complications. |
| Hyams *et al.* [46] | Indiana pouch: 2, ileal conduit: 8, orthotopic neobladder: 5 | 15 | Kidneys:5 | n/r | n/r | n/r | Assessment of different access methods in the management of urolithiasis in patients with urinary tract reconstruction. |
| El-Nahas *et al.* [47] | Ileal neobladder: 10, ileal conduit: 4, hemi-Kock pouch: 7, rectal: 3 | 24 | Kidneys: 20 Ureters: 4 | 40 (14–132) | 50% struvite; 41.7 calcium; 8.3 urine acid | 87.5% | Percutaneous management of large burden kidney and ureteric stones; 12.5% complication rate; recurrent stones treated with ESWL. |
| Paez *et al.* [48] | n/r | 12 | Reservoir: 12 | 23.6 | n/r | 58% | Ultrasound-guided percutaneous access. No intra/postoperative complications. Five (42%) stone recurrences with the mean time to recurrence of 18 months. |
| Roberts *et al.* [49] | Bladder neck reconstruction: 11, bladder augmentation: 4, bladder augmentation + catheterizable channel: 25, catheterizable reservoir: 15, neobladder: 2 | 60 | Reservoir: 60 | 48.7 | n/r | Intact stone extraction: 57.6%; fragmented: 56.1% | Intact vs fragmented extraction; 103 stone episodes in 60 patients found no difference in extraction methods. Average time from reconstruction to stone formation or recurrence was 37 months. |
| Natalin *et al.* [50] | Indiana pouch: 5 | 5 | Reservoir: 5 | 32.5 (9–61) | n/r | 100% | Combined endolaparopscopic double-percutaneous method for large burden reservoir stones. No intra/postoperative complications. |
| Deliveliotis *et al.* [51] | S-pouch: 3, Bricker: 8 | 11 | Kidneys: 7 Ureter: 5 | 4.5 years (1–9 years) | Struvite, urine acid with calcium deposits | 81.8% | ESWL for upper tract calculi in patients with urinary diversion. Four patients failed; two patients received repeated ESWL and two underwent percutaneous nephrolithotomy and ureterolithomy; no complications recorded. |
| El-Assmy *et al.* [52] | Ileal W neobladder: 11, Bricker conduit: 8, Kock pouch: 6, rectal bladder: 2 | 27 | Kidneys: 21 Ureter: 3 | 3 | n/r | 81.5% | Repeated ESWL in 12 (44.4%) patients; eight (29.6%) required two sessions, four (14.8%) required three sessions. Two patients required percutaneous nephrolithotomy. 7.4% minor postoperative complications. |

*n/r, not recorded.*

## CONCLUSIONS

Advances in the area of bladder substitution have enabled patients to maintain an excellent health-related quality of life following urinary diversion, but diversion-associated urolithiasis remains a problem for these patients. Fortunately, advances in endourological equipment and techniques have greatly reduced the morbidity of this common problem (Table 1, [44–52]). Prevention of recurrent stones with correction of metabolic abnormalities, increased fluid intake, pouch irrigation protocols, and prophylaxis against recurrent infections are critical steps in avoiding recurrent stones.

## CONFLICT OF INTEREST

None declared.

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