Francesca Suriano^a
Siamak Daneshmand^b
Maurizio Buscarini^a

^aCampus Bio-Medico, University of Rome, Rome, Italy; ^bUSC Institute of Urology, Los Angeles, Calif., USA

Use of Nonabsorbable Staples for Urinary Diversion: A Step in the Wrong Direction

Key Words

Urinary diversion • Metabolic changes • Nonabsorbable staples • Pouch stones • Management of calculi

Abstract

Background: The use of bowel segments incorporated into the urinary tract is well established in urological surgery. **Objective:** To describe and compare the use of absorbable and nonabsorbable staples for creation of a urine reservoir after radical cystectomy. **Materials and Methods:** This review is based on a systematic Medline search assessing the period 1950–2010. **Results:** Use of the autosuture stapling device for the construction of the urinary diversion significantly reduces operating time. Johnson and Fuerst reported its use for the first time to construct a ureteroileocutaneous urinary diversion in 1973. However, many studies demonstrated that exposed metal staples represent a nidus for stone formation when they are in direct contact with urine, particularly in urinary diversions such as Kock pouch and ileal conduit. Stone formation has been attributed in part to the use of nonabsorbable artificial materials, such as metal staples and Marlex mesh, strictures of the pouch and accumulation of mucus. The treatment options for pouch calculi include observation for spontaneous passage, extracorporeal shockwave lithotripsy, percutaneous or endoscopic lithotripsy/lithotomy. **Conclusions:** Historically, the mean time to stone formation

with nonabsorbable material (staples, Marlex mesh) is 34 months. None of the studies on use of nonabsorbable staples in urinary diversion has such a long follow-up. Until further studies with more appropriate observation time are completed, the use of nonabsorbable staples for continent and noncontinent urinary diversion should be discouraged.

Copyright © 2012 S. Karger AG, Basel

Introduction

The use of bowel segments incorporated into the urinary tract is well established in urological surgery [1]. Metabolic complications may occur in patients with urinary intestinal diversion as a result of the resorption of urinary solutes across the bowel segment, including serum electrolyte abnormalities, bony demineralization and calculus formation [1–10].

Since 1981, several authors have described using nonabsorbable staples for the creation of ileal conduit, continent pouches and orthotopic reservoir after radical cystectomy. The supposed advantages of these techniques range from shorter duration of the procedure, ease of use and availability. The vast majority of studies describe a very high rate of stone formation in urinary diversion. Steel or titanium staples used for linear application may extrude into the reservoir. Urinary stasis due to impaired

voiding, urinary infection with urea splitting organism, encrustation on foreign bodies and exposed metallic staples, mucus as well as metabolic acidosis are all contributing factors for stone formation. Vermeulen et al. [3] demonstrated that stones form around a wide variety of foreign bodies (clay, lead, chalk, zinc, paraffin, polythene, porcelain and silk sutures) in the absence of infection or a change in urinary pH.

The ideal suture for use within the urinary tract should maintain its strength until wound repair is satisfactory, and then undergo total absorption without promoting stone formation.

Materials and Methods

Pathogenesis of urinary calculi following diversion was hypothesized for the first time by Dretler in 1973 [5]: excess conduit length or conduit dysfunction enhances chloride-bicarbonate exchange; chronic bicarbonate loss creates a need for bone buffering, which results in hypercalciuria which in the presence of an alkaline urine creates a favorable milieu for calculus precipitation.

Mucus produced by the intestine may also play a role. Small crystals can adhere to mucus, which could augment crystal retention and aggregation. It is also hypothesized that mucus may serve as a template for bacterial biofilm formation [11].

Osther et al. [12] compared urinary biochemical and physicochemical environments in patients who had undergone bladder substitution with the ileal-urethral Kock reservoir, and who had no actual urinary infection, with those of healthy subjects. They observed that the most striking findings were lower urinary excretion rates of citrate and higher urine pH in patients compared with controls. Urinary calcium excretion was significantly higher in the healthy controls with no difference in total urinary ammonia excretion between patients and controls. These findings were reflected in significantly higher levels of urinary supersaturation with respect to calcium oxalate, calcium phosphate, brushite and magnesium ammonium phosphate, in patients with urinary diversion.

Most stones were reported to be infectious, comprised of struvite and/or carbonate apatite. The surface characteristics of the foreign body appear to have an important influence on the frequency of calculus formation. Ball et al. [13] found a higher incidence of calculi in association with rough glass beads than with smooth beads. In addition, the rough beads appeared to be more irritating to the bladder than the smooth beads, as evidenced by the higher average number of epithelial cell layers, and more frequent and intense proliferative and metaplastic changes in the epithelium.

The kind of urinary diversion following cystectomy could play a role in stone formation. Terai et al. [1] suggested that continent reservoir is associated with higher incidence of stone formation than an ileal conduit. They studied the effect of urinary intestinal diversion on risk factors for calcium urolithiasis in three groups of patients (Kock pouch, Indiana pouch and ileal conduit) and reported a difference of mean urinary excretions of calcium, phosphate and magnesium; these were significantly

greater in the continent reservoir group than in the ileal conduit group.

The highest incidence of stone formation described in the literature is reported in patients with a Kock pouch (17–27%) [8, 14]. The Indiana pouch is a continent urinary diversion in which there are no foreign materials permanently in contact with urine. Terai et al. [15] investigated the characteristics of stone formation in patients with the Indiana pouch (54 patients) and compared them with those with a Kock pouch (72 patients). Their minimum follow-up was 12 months. Of the 54 patients with an Indiana pouch, urinary stones developed within the reservoir in 7 (12.9%); of these, 70% were not associated with foreign materials. In contrast, urinary calculi developed in 31 of 72 patients with a Kock pouch (43.1%).

Other series have also reported a low rate of stone formation in the Indiana pouch. Arai et al. [16] reported pouch urolithiasis in 5 of 45 patients (11%) with a follow-up of 46 months. In another study, Arai et al. [14] compared the postoperative complications and long-term follow-up of Kock (53 months) and Indiana pouches (34 months) and described development of stones in 26.5 and 5.4%, respectively.

Brenner and Johnson [17] described a low incidence of calculi secondary to encrustation around the metal staples in patients undergoing cystectomy and ureteroileocutaneous urinary diversion (1 of 34 patients). Their follow-up ranged from 1 to 161 months (average 50 months).

Fontana et al. [18] reported the clinical and functional outcomes of 53 patients who underwent cystectomy and Y-shaped stapled ileal neobladder. The median follow-up was only 20 months. Three patients (6%) developed neobladder stones, which were treated through an endoscopic approach.

Montie et al. [19] compared a W-absorbable stapled ileal neobladder with hand-sewn ileal (Studer) or hand-sewn ileocolic (Le Bag) reservoir. They observed that the W-configuration made with staples does not provide an absolutely spherical shape even though it was hoped that functionally the shape would be satisfactory. The W-stapled reservoir may not have adequate physical parameters to provide a low pressure, highly compliant reservoir. The authors commented that failure of the reservoir to distend could be a function of reservoir design, areas of ischemia in the reservoir, or reaction to staple material.

Conversely, absorbable staples on the GIA instrument may work satisfactorily for formation of an ileocolic reservoir for continent cutaneous diversion. They concluded that although use of absorbable staples on a GIA stapler was safe and allowed rapid construction of the reservoir, the inconsistencies of the results discouraged its use particularly in the described configurations.

Augmentation cystoplasty has become a preferred surgical method of managing incontinence in neurogenic or congenitally malformed bladders in children. Palmer et al. [20] reviewed 48 patients undergoing augmentation cystoplasty from 1981 to 1991. Patient follow-up ranged from 9 months to 9 years (mean 4 years). Urolithiasis occurred in 21 of 40 patients (52.5%), recurrent calculi formed in 4 of 21 children (19%). The median time for calculus formation after cystoplasty was 24.5 months (range 2–72 months). They found a statistically significant relationship between urinary tract infection and urolithiasis. Urinary stasis and/or mucus in the reservoir base, or in pockets of the augmented segments, that are not optimally spherical, provide sources for infection and calculus formation from residual mucus.

The overall complication rate of the intussuscepted afferent segment required for the construction of a continent Koch reservoir led to the development and description of the continence and anti-reflux 'T-mechanism' by Skinner's group in the late 1990s. Based on the subserosal appendix tunneling described by Mitrofanoff and the extraserosal ureteric-tunnelling by Ghoneim, this new mechanism has been successfully incorporated into an orthotopic diversion system (T-neobladder or T-pouch). Apparently, this T-mechanism has eliminated the problems associated with the intussuscepted intestinal segment, while maintaining an effective antireflux and continence system [21].

Stein et al. [22] reported a series of 209 patients who underwent construction of an orthotopic T-pouch ileal neobladder after cystectomy with a median follow-up of 33 months. They had good results in terms of urinary flow, which was unobstructed in 95% of patients, and in terms of reflux prevention (90%); but the most common late diversion complication was pouch calculi (17 on 209 patients). Even though it is a 'serous lined extramural ileal flap valve', staples become exposed over time and lead to stone formation. This has led to later modification of the technique with removal of the stapled line.

The treatment modality selected depends on the size, location, and composition of the stone and the surgeon's experience. With improved endourologic procedures, the management options for stone disease in patients with urinary diversion have shifted to minimally invasive procedures. Most pouch stones can now be managed endoscopically.

Some authors have reported open pouchlithotomy as a primary management of large orthotopic reservoir stone burden. Madbouly [23] published his series of 3,933 patients undergoing cystectomy and orthotopic urinary diversion. Pouch stones were present in 17.9% patients, and all stones but 12 were managed endoscopically. The median interval to stone detection was 99 months. Open pouch lithotomy of large reservoir stone burden was performed in 12 patients: none showed stone recurrence; all had sterile urine cultures except one, and the upper tract was maintained as preoperatively.

Anatomical knowledge of the type of diversion is essential to adequately and safely treat the patient. L'Esperance et al. [24] described management of stones in different urinary diversions. Although there are metabolic variations between the different loop incontinent diversions (jejunal, transverse, colon, sigmoid colon), the surgical management is similar. Stones within the loop are usually a result of either stomal stenosis, foreign body reaction, or passage from the upper tract. Stones formed around foreign bodies are usually the result of residual staples or suture placed at the time of formation of the loop. In this setting, removal of the foreign body is essential. When a Wallace type anastomosis has been performed, a retrograde approach can be attempted. A percutaneous approach is often necessary in dealing with upper tract stones. One interesting modification is the use of percutaneous access to allow for antegrade advancement of a wire into the loop and the subsequent use of retrograde approach in dealing with the upper tract stones.

Extracorporeal shockwave lithotripsy (ESWL) is a reasonable option in patients with small upper tract stones. Boyd et al. [25] used ESWL successfully for inaccessible small stones in the afferent valve of the Kock pouch. The pulverized stone fragments required removal from the pouch to prevent them from acting as a nidus for continued stone formation.

When the stone burden is low in an orthotopic neobladder, transurethral techniques with intracorporeal lithotripsy can be utilized. However, when stone burden is extensive open cystolithotomy should be performed [23]. Recently, percutaneous access to the pouch has been described: with the introduction of a laparoscopic entrapment sac [24], or with Amplatz sheaths. In the setting of continent cutaneous diversion stones, a single access with use of a rigid nephroscope may be adequate. In cases with minimal stone burden, flexible pouchoscopy through the stoma may be acceptable [24].

Results

Intestinal urinary diversion has gained widespread use in patients with congenital anomalies and neuropathic bladder disorders in addition to its use following radical cystectomy. Ileal, jejunal, and colonic segments have been used in a variety of refluxing, nonrefluxing, incontinent, and continent procedures.

The literature contains conflicting reports regarding the actual incidence of stone formation in urinary diversion. Early surgeons who used surgical staples reported a high incidence of ileal conduit calculi. Assadnia et al. [26] described stones around metal staples in 2 of 5 patients underwent ureteroileocutaneous urinary diversion. Bergman et al. [27] reported conduit stone formation in 1 of 2 patients in whom they had used surgical staples. These authors concluded that surgical staples have no place in urologic operations because of high risk of calculi.

Takeda et al. [28] described stone formation in 12 patients who underwent urinary diversion, with a mean follow-up of 10.8 months. They observed that the use of nonabsorbable staples is not sufficient for pouch urolithiasis. Patients with stones had two or more risk factors such as hypercalciuria, hyperoxaluria, hypomagnesuria. They concluded that urinary diversion should be not performed in patients with two or more risk factors. Perhaps a preoperative metabolic evaluation should be performed to identify those patients at greater risk of stone disease to exclude them from the option of nonabsorbable staples for urinary diversion [15, 29].

Moreover, there is evidence of kidney stone formation around refluxed surgical staples [5, 30]. This may have developed in 4–10% of the patients undergoing ureteroileocutaneous diversion during prolonged observation [31]. Urinary diversion, such as ileal conduit, is frequently associated with free reflux of urine from the conduit to the kidneys. This can carry up to the kidneys any foreign body from the conduit, like surgical staples, which can act

as a nidus for stone formation. These calculi are usually infectious stones (struvite), associated with urinary tract infection with urea-splitting organisms, mainly *Proteus mirabilis*.

In an effort to refine the Kock pouch, several modifications were made in the creation of the pouch, which included replacing the Marlex mesh collar with absorbable polyglycolic acid mesh, customizing titanium stapling cartridges, and using 3 rows of staples instead of 4, with fixation of the nipple to the wall of the reservoir with the third row of staples applied from the outside to prevent staple exposure to the urine [9]. As a result, the incidence of stones dropped from 16 to 10% in 383 patients [8].

The first absorbable staple, polysorb 55 lactomer copolymer was developed in 1982. These staples are absorbed in tissue via hydrolysis rather than polynuclear phagocytosis, thus reducing necrosis in the tissues and improving wound healing. Wheelless [32] reported use of the TA-55 polysorb staples to close cystostomies and proximal end of ileal loops, suggesting that using absorbable staples reduce the incidence of stone formation.

The use of absorbable staples significantly decreases the operative time, around 20 min less than hand-sewn reservoir like described by Montie et al. [19]. But its widespread use has been restricted due to problems related to reservoir malfunction, in particular during the construction of the W-configured ileal reservoir, and the greater costs, which neutralizes the savings realized by the reduced operative time [19, 33]. An acceptable alternative could be titanium staples, which are cheaper than the absorbable ones and are available for laparoscopic procedures. Furthermore, non-absorbable titanium staples, because of its corrosion-resistant nature and low toxicity, seem to be well tolerated inside the urinary tract, and thus have been safely used dur-

ing the construction of urinary reservoir [12]. Moreover, bowel mucosa rapidly covers most of staple lines within the reservoir; however, stone formation still can occur at a rate of up to 6% [18]. The mean time to stone formation is 34 months, suggesting that most series do not have sufficient follow-up to capture these complications. It seems logical that, with longer follow-up, we will see more cases of staple encrustations or stones.

It is well known that the urine of patients with urinary diversion is more prone to stone formation. This is due to altered metabolism, chronic calcium resorption, acidosis and decrease in citrate. The idea of deliberately leaving a foreign body in permanent contact with stone-forming urine seems, at best, naïve. The widespread use of nonabsorbable sutures in urinary diversion would no doubt lead to a higher rate of stone formation. Can we justify the occurrence of this preventable complication with slight reduction of operating time?

Greater attention should be given to the quality of life of patients undergoing radical cystectomy for bladder carcinoma and urinary diversion.

Conclusions

The aim of orthotopic neobladder reconstruction should be improvement in the patient's quality of life by ensuring both good continence and adequate voiding, as well as to preserve the integrity of the upper urinary tract and avoid metabolic disorders. We can conclude that until studies with longer follow-up (at least more than 3 years) are reported, the use of nonabsorbable staples in the construction of urinary diversion should be discouraged.

References

- 1 Terai A, Arai Y, Kawakita M, Okada Y, Yoshida O: Effect of urinary intestinal diversion on urinary risk factors for urolithiasis. *J Urol* 1995;153:37–41.
- 2 Johnson DE, Fuerst DE: Use of autosuture construction of ileal conduits. *J Urol* 1973; 109:821–823.
- 3 Vermeulen CW, Grove WJ, Goetz R, Ragins HD, Correll NO: Experimental urolithiasis. Development of calculi upon foreign bodies surgically introduced into bladders of rats. *J Urol* 1950;64:541–548.
- 4 Golomb J, Klutke CG, Raz S: Complications of bladder substitution and continent urinary diversion. *Urology* 1989;34:329–338.
- 5 Dretler SP: The pathogenesis of urinary tract calculi occurring after ileal conduit diversion: I. Clinical study. II. Conduit study. III. Prevention. *J Urol* 1973;109:204–209.
- 6 Gronau E, Pannek J: Reflux of a staple after Kock pouch urinary diversion: a nidus for renal stone formation. *J Endourol* 2004;18: 481–482.
- 7 Stein JP, Freeman JA, Esrig D, et al: Complications of the afferent antireflux valve mechanism in the Kock ileal reservoir. *J Urol* 1996; 155:1579–1584.
- 8 Ginsberg D, Huffman JL, Lieskovsky G, Boyd S, Skinner DG: Urinary tract stones: a complication of the Kock pouch continent urinary diversion. *J Urol* 1991;145: 956–959.
- 9 Skinner DG, Lieveskosky G, Boyd SD: Continuing experience with the continent ileal reservoir (Kock pouch) as an alternative to cutaneous urinary diversion: an update after 250 cases. *J Urol* 1987;137:1140–1145.
- 10 Hall MC, Koch MO, McDougal WS: Metabolic consequences of urinary diversion through intestinal segments. *Urol Clin North Am* 1991;18:725–735.

- 11 Blyth B, Ewalt DH, Duckett JW, Snyder HM: 3rd lithogenic properties of enterocystoplasty. *J Urol* 1992;148:575–579.
- 12 Osther PJ, Poulsen AL, Steven K: Stone risk after bladder substitution with the ileal-urethral Kock reservoir. *Scand J Urol Nephrol* 2000;34:257–261.
- 13 Ball JK, Field WEH, Roe FJC, Walters M: The carcinogenic and co-carcinogenic effects of paraffin wax pellets and glass beads in the mouse bladder. *Br J Urol* 1964;36:225–237.
- 14 Arai Y, Kawakita M, Terachi T, et al: Long term follow-up of the Kock pouch and Indiana pouch procedures. *J Urol* 1993;150:51–55.
- 15 Terai A, Ueda T, Kakehi Y, et al: Urinary calculi as a late complication of the Indiana continent urinary diversion: comparison with the Kock pouch procedure. *J Urol* 1996;155:66–68.
- 16 Arai Y, Shichiri Y, Miyakawa M, et al: Evolving experience with continent urinary diversion using the Indiana pouch. *Int J Urol* 1994;1:241–245.
- 17 Brenner M, Johnson DE: Ileal conduit calculi from stapler anastomosis: a long term complications? *Urology* 1985;26:537–540.
- 18 Fontana D, Bellina M, Fasolis G, et al: Y-neobladder: an easy, fast, and reliable procedure. *Urology* 2004;63:699–703.
- 19 Montie JE, Pontes JE, Powell IJ: A comparison of the W-stapled ileal reservoir with hand-sewn reservoir for orthotopic bladder replacement. *Urology* 1996;47:476–481.
- 20 Palmer LS, Franco I, Kogan SJ, Reda E, Gill B, Levitt SB: Urolithiasis in children following augmentation cystoplasty. *J Urol* 1993;150:726–729.
- 21 Stein JP, Lieskovsky G, Ginsberg DA, Bochner BH, Skinner DG: The T-pouch: an orthotopic ileal neobladder incorporating a serosal lined ileal antireflux technique. *J Urol* 1998;159:1836–1842.
- 22 Stein JP, Dunn MD, Queck ML, Miranda G, Skinner DG: The orthotopic T pouch ileal neobladder: experience with 209 patients. *J Urol* 2004;172:584–587.
- 23 Madbouly K: Large orthotopic reservoir stone burden: role of open surgery. *Urol Ann* 2010;2:96–99.
- 24 L'Esperance JO, Sung J, Marguet C, L'Esperance A, Albala DM: The surgical management of stones in patients with urinary diversion. *Curr Opin Urol* 2004;14:129–134.
- 25 Boyd SD, Everett RW, Schiff WM, et al: Treatment of unusual Kock pouch urinary calculi with extracorporeal shock wave lithotripsy. *J Urol* 1988;139:805–806.
- 26 Assadnia A, Lee CN, Petre JH, Lyons RC: Two cases of stone formation in ileal conduits after using staple gun for closure of proximal end of isolated loop. *J Urol* 1972;108:553.
- 27 Bergman SM, Sears HF, Javadpour N: Complication with mechanical stapling device in creation of ileoconduit. *Urology* 1978;12:71–73.
- 28 Takeda M, Katayama Y, Takahashi H, et al: Incidence of pouch stones and risk factors for urolithiasis in patients with continent urinary diversion or neobladder using intestine. *Urol Int* 1994;52:21–25.
- 29 Abreu SC, Araujo MB, Silveira RA, et al: Laparoscopic assisted radical cystectomy with U-shaped orthotopic ileal neobladder constructed using nonabsorbable titanium staples. *Urology* 2006;68:193–197.
- 30 Golomb J, Fuchs G, Klutke CG, Stenzl A, Raz S: Kidney stone formed around refluxed surgical staple and removed by transurethral endoscopic manipulation. *Urology* 1991;38:338–340.
- 31 Richie JP, Skinner DG: Ureterointestinal diversion; in Walsh PC, Gittes RF, Perlmutter AD, et al (eds): *Campbell's Urology*. Philadelphia, WB Saunders, 1986, vol 3, p 2601.
- 32 Wheelless CR: Stapling techniques in operations for malignant disease of the female genital tract. *Surg Clin North Am* 1984;64:591–608.
- 33 Dall'Oglio MF, Nesrallaah LJ, Rodrigues P, et al: The use of absorbable mechanical suture in orthotopic ileal neobladder replacement. *Braz J Urol* 2000;26:288–292.