Ureteric reconstruction and replacement

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Purpose of review

To review the recent advances on ureteric reconstruction and replacement, in particular, ileal ureteric replacement and laparoscopic and robotic-assisted ureteral reconstruction.

Recent findings

Recently, the ureteric replacement with bowel has been carefully assessed by several authors, and the results are quite impressive. Also, very recent studies on laparoscopic and robotic-assisted ureteral repair have been published. Outcomes appear very promising, allowing for a faster recovery and shorter hospital stay for the patient.

Summary

Today, we can conclude that the field of ureteric reconstruction and replacement is still evolving. Old techniques are supported by an increasing degree of evidence, and new, more minimally invasive surgical strategies emerge. Clearly, there are some disadvantages as well as difficulties to overcome with the new techniques; however, recent studies appear to present promising results.

Keywords

iatrogenic injury, surgery, ureter, ureteral reconstruction, ureteral repair, ureteral replacement

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Introduction

The reasons necessitating reconstruction or replacement of the ureter are manifold and include different kinds of trauma, ureteric removal due to extensive tumour growth [1] or inflammatory conditions such as retroperitoneal fibrosis [2] or tuberculosis [3], ureteric anomalies, undiversion procedures and, of course, various kinds of deliberate reconstructions due to neurogenic bladder dysfunction, such as continent and incontinent diversionary procedures.

Trauma

A trauma to the ureter can be either extrinsic or iatrogenic. Ureteral injuries after external violence are quite rare, occurring almost exclusively in cases of penetrating trauma (however, ureteropelvic disruptions may occur after a blunt trauma) such as gunshots or knife attacks. Trauma to the ureter in conjunction with penetrating external trauma is almost always associated with the injury of other adjacent organs.

The ureter is at potential risk during surgery in the lower abdomen and pelvis. Gynaecological procedures, with hysterectomy as the most pronounced, seem to be the commonest origin for these injuries [4–7], and it has been suggested that the introduction of laparoscopy in benign gynaecological surgery could possibly have increased the frequency of injuries [8]. The patients risk side-effects such as infections, leakage and loss of renal function. Sometimes, such injuries may heal spontaneously, or after a period of stenting, but frequently reparative measures will be necessary.

Undiversion

The role of urinary undiversion has undergone changes over the past decades. In the preclean intermittent self-catheterization (CISC) period, complex reconstructive procedures were generally avoided because of an inability to empty the bladder after the reconstruction. Many patients were instead initially treated with permanent urinary diversions using a bowel segment. However, it became apparent that all kinds of diversionary procedures carry a considerable risk of adverse effects, either immediately or over time [9,10]. The risk of adverse reactions is correlated with the complexity of the reconstruction, the more complex and advanced reconstruction, the more considerable the risk of complications. Nevertheless, already some 30 years ago, it was recognized that incontinent urinary diversion *ad modum* Bricker also might be associated with possible long-term complications [11]. Upon increased awareness of such

complications, together with the implementation and subsequent routine use of CISC, urinary undiversion became a part of the treatment armamentarium for the reconstructive surgeon [12].

Anomalies

Ureteric anomalies are relatively common, but even though such conditions may be associated with the impairment of renal function, they can frequently be without clinical relevance, perhaps only accidentally revealed during radiological investigation for other reasons. Ureteric anomalies can be divided into anomalies of termination, structure and number. The recognition of a clinically relevant anomaly may necessitate ureteric reconstruction or, although seldom, replacement.

This study reviews recent literature regarding ureteric repair, with special reference not only to the introduction of laparoscopic and robotic techniques but also to recent reports on the feasibility of the use of intestinal segment for ureteral replacement. The contemporary role of transureteroureterostomy will also be briefly addressed.

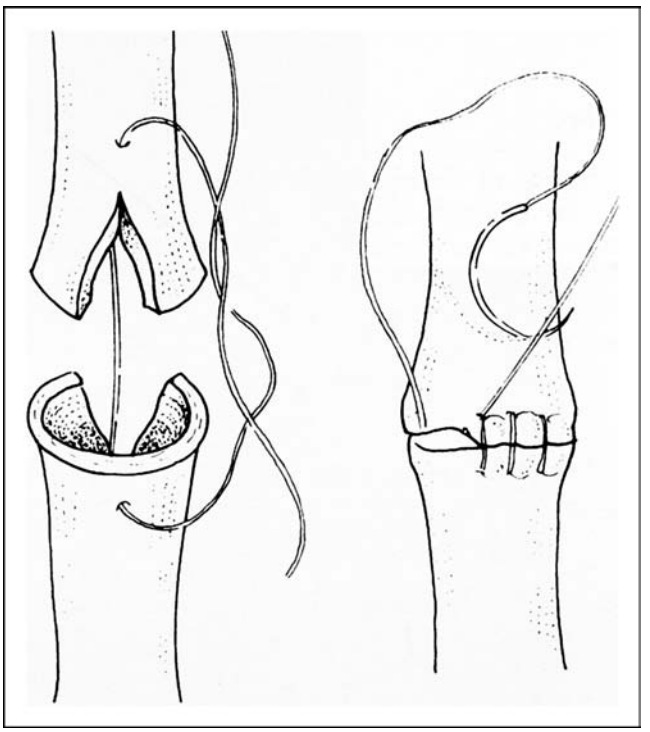
Diagnostics

A fast and correct diagnosis of an injury to the ureter requires the surgeon to be attentive to certain alarming signs that may present during or after surgery, such as haematuria, oliguria, peritonitis, loin pain, elevated serum creatinine or severe leakage (fistula to the vagina?). Gas distension of the bladder catheter bag is of course an important and alarming sign, practically proving bladder or ureteral injury. Intraoperative recognition of course requires a high degree of attention, but specific vigilance may decrease the incidence of missed injuries. During extrinsic violence, the trajectory of the penetrating item should be carefully examined. Excretory urography or contrast-enhanced computed tomography, or both can be very valuable in the diagnosis. In cases of late recognition of a ureteral injury, a nephrostomy tube is frequently inserted through which an antegrade ureterography can be performed in order to reveal the degree, type and level of the injury. In such cases, the estimation of the function of the affected renal unit is advocated, principally due to medico-legal reasons [13].

Traditional techniques for ureteral repair

Various techniques have been suggested for ureteral repair, but they generally encompass careful preservation of the vascular supply as well as a sufficient mobilization of the ureter and the construction of a tension-free anastomosis [14,15]. The chosen technique is strongly dependent on the type and the localization of the injury. Upon immediate recognition, ureteral injuries can frequently be subjected to primary repair with a tension-free, spatulated ureteroureterostomy (Fig. 1). For secondary reparation of a very distal injury (Fig. 2a), a ureteroneocystostomy may be preferred, which generally can be performed via an extraperitoneal approach. After healing, a satisfactory ureteral patency can be radiologically assessed (Fig. 2b). In cases of late recognition of a more proximal injury (Fig. 3a), the radiographic investigation may be sharpened with combined ureterography (Fig. 3b) in order to preserve the distal ureteral segment, hence allowing for secondary repair with end-to-end ureteroureterostomy, which may yield an excellent outcome (Fig. 3c). If the distal segment is judged unsuitable to incorporate in the reconstruction, a psoas hitch can be done (Fig. 4). If the injury is too proximal even for a psoas hitch reconstruction, can be accomplished using the Boari flap technique (Fig. 5) with which the surgeon can achieve an anastomosis without tension even for rather proximal injuries.

Figure 1 Diagrammatic representation of primary repair with a tension-free, spatulated ureteroureterostomy



In cases of a long delay before recognition of an iatrogenic ureteral injury, renal function may be severely compromised. Nephrectomy can then be the choice of treatment as it also can be in cases of persistent ureterovaginal fistula despite several efforts to repair. Nephrectomy may also be contemplated for patients treated with radiation to the lesser pelvis, providing that the function of the contralateral kidney is good, as well as in cases of trauma with

Figure 2 Radiographic assessment of secondary reparation of a very distal injury

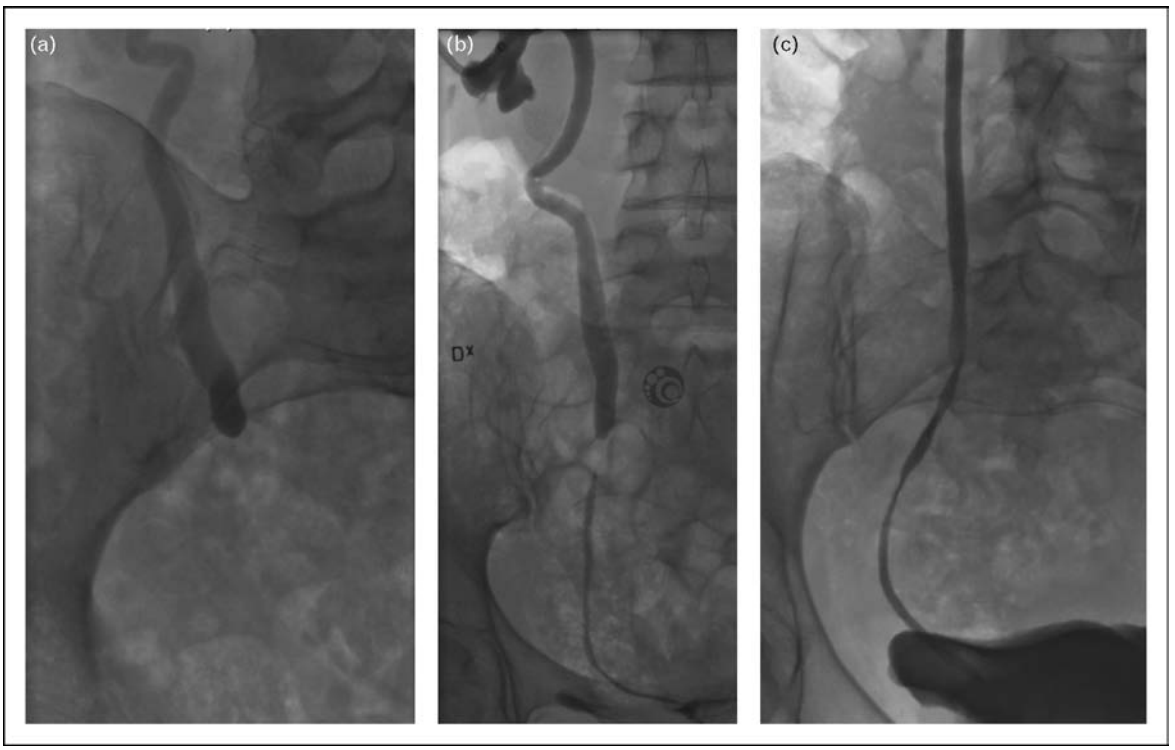
associated injuries to other viscera, severe injury of the kidney or complete destruction of the entire ureter. Renal autotransplantation should be reserved for cases with very advanced ureteral injury and perhaps also after several failed attempts to repair the injury in a more conservative manner.

The use of intestinal segments for ureteral replacement

Intestinal replacement of the ureter dates back to more than 50 years [16]. It is generally performed only after careful consideration, and after that other methods, which do not include harvesting and incorporation of bowel into the urinary tract, have been tried and failed or primarily deemed inappropriate or impossible to use. Even though ureteral replacement with bowel is a complex reconstruction technique, as well as associated with potential complications, it remains an important treatment tool. Examples of indications are severe cases of irreparable ureteral stricture due to retroperitoneal fibrosis, iatrogenic panureteric injury such as complete avulsion of the ureter in conjunction with ureteroscopy, stenosis of the pelvoureteral junction refractory to other surgical measures and ureteral carcinoma with a single system or compromised renal function on the contralateral side.

In a recent study, Chung *et al.* [17] reported long-term results on a large series of 56 patients, the vast majority having undergone ileal replacement. Follow-up data included excretory urogram or equivalent imaging results and measurement of serum chloride, bicarbonate and creatinine before and after the procedure. Overall, the complication rate remained low. Most postoperative complications, which occurred in 10 patients, were minor in nature, including pyelonephritis, hernia, recurrent urolithiasis and deep venous thrombosis. Major complications (six patients) included anastomotic stricture, ileal graft obstruction and chronic renal failure. The authors themselves concluded that intestinal ureteral

Figure 3 Radiographic representation of late recognition of a more proximal injury



substitution remains a well tolerated and efficacious procedure in patients with complex and difficult ureteral issues not amenable to more conservative measures. However, it should be pointed out that the safety appears limited, as more than 10% of the patients experienced severe complications. Renal damage was infrequent, although a refluxing system was adopted, and these findings tally with the notion put forward by Hinman and Oppenheimer [18] already 50 years ago that a long isoperistaltic ileal segment in fact carries antireflux properties.

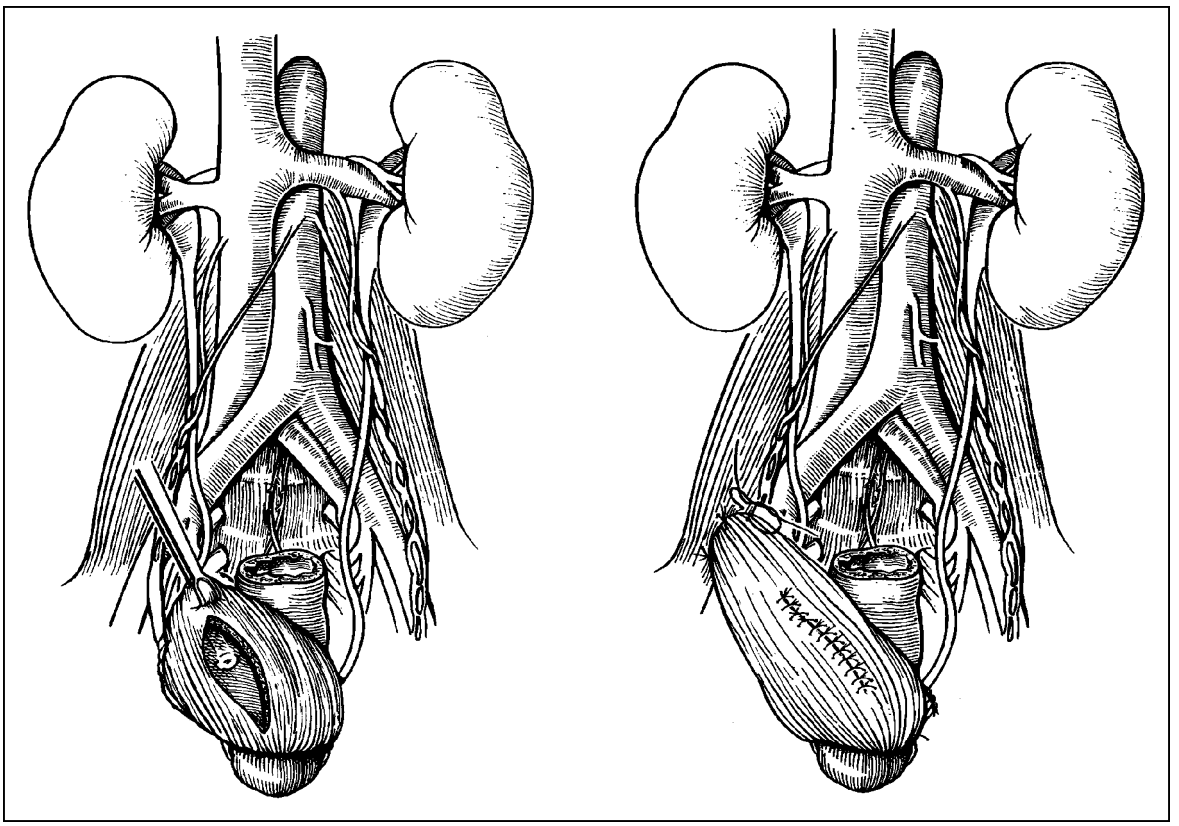
Corroborating these results, Armatys *et al.* [19•] very recently published their results derived from an even larger cohort of 91 patients. Indications for an ileal ureter were radiation-induced stricture, iatrogenic injury in 16 patients and retroperitoneal fibrosis. Only four patients had primary ureteral cancer. Long-term complications included anastomotic stricture in three patients and fistula in six. Serum creatinine decreased or remained stable in 68 patients (74.7%), and hyperchloremic metabolic acidosis developed in three. The authors concluded that the ileal ureter is a reasonable option for long-term ureteral reconstruction with preserved renal function in carefully selected patients.

Recently, Kamat and Khandelwal [20] reported on laparoscopy-assisted reconstruction of a long-segment ureteral stricture using reconfigured ileal segment according to the Yang–Monti principle. The procedure was successful, and potential advantages of applying this technique include a minimized ileal surface area exposed to urine possibly avoiding metabolic consequences associated with the incorporation of a long-bowel segment.

The use of laparoscopy and robotics in upper urinary tract reconstruction

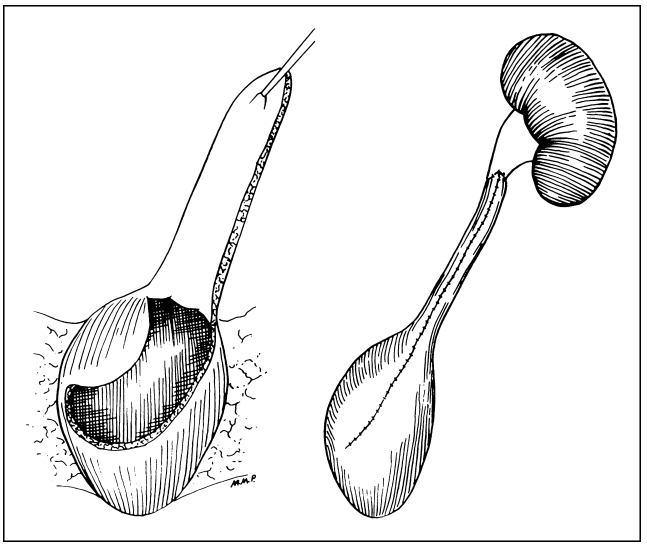
Although laparoscopic surgery has been adopted and advocated for various kinds of ureteral reconstruction, comparisons of open versus laparoscopic reconstructive ureteral surgery have been lacking until recently when Simmons *et al.* [21] reported on their retrospective series comparing laparoscopic ($n = 12$) and open ($n = 34$) ureteroureterostomy, ureteroneocystostomy and Boari flap procedures. The open surgical group had greater operative blood loss and a somewhat longer hospital stay compared with the laparoscopic group. There was no statistically significant difference in overall complication rate between the two groups. Ureteral patency was successfully re-established in all in the laparoscopic group at a mean follow-up of 23 months. In the open group, patency had been achieved in 30 patients at a mean follow-up of 43 months.

Figure 4 Diagrammatic representation of the reconstruction using a psoas hitch



One obvious weakness with this study of Simmons *et al.* [21] was of course the nonrandomized fashion, the controls being historical or 'patient selection for the open versus laparoscopic groups influenced predominantly by patients and surgeons preference'. However, patient demographics and ureteral stricture cause, location and length were reported to be equivalent between the two groups.

Figure 5 Diagrammatic representation of the reconstruction using a Boari flap technique



The advantages of robotic-assisted laparoscopy in comparison with conventional laparoscopic surgery include endowrist technology, tremor elimination, stereoscopic three-dimensional vision and perhaps also improved ergonomics. Robotics has already been extensively used for radical prostatectomy, however, also expanding into other fields of urology, including reconstruction of the upper urinary tract. Dismembered laparoscopic pyeloplasty, according to Anderson–Hynes, has challenged open pyeloplasty since several years with reports on satisfactory outcome and decreased morbidity as compared with open surgery [22]. A wide implementation of laparoscopic pyeloplasty has, however, been hampered because of the need for rather long intracorporeal suture lines [23], but using robotic techniques appears to allow for a better precision in this context.

In a very recent study, Mufarrij *et al.* [24••] presented their multi-institutional experience encompassing 140 patients, from three university hospitals, who had been subjected to robotic dismembered pyeloplasty. Of the

cases, 117 were primary repairs and 23 secondary repairs. Mean operative time was 217 min, estimated blood loss was 59 ml, mean length of hospital stay was 2 days and mean follow-up was 29 months. Radiographic resolution of obstruction was noted in 134 patients. Ten patients in the entire cohort, however, experienced major complications.

Schwentner *et al.* [25] reported on a large series of 92 patients who had been subjected to transperitoneal robot-assisted laparoscopic pyeloplasty for pelvi-ureteric junction obstruction using the daVinci system. The mean follow-up was 39.1 months, with a resolution of the obstruction in 89 patients. There were no late complications. The authors, moreover, stated that the robotic approach was easy and quick to learn for both the surgical and the technical staff.

The study from Yanke *et al.* [26] is in line with the above mentioned, with a good outcome after robotic pyeloplasty; however, their series was smaller (29 patients). Procedures in two patients, encountered early in their series, required open conversion. There were no recurrences based on subjective as well as radiological measures. The authors concluded that robotic pyeloplasty is a technically feasible management option for obstruction of the ureteropelvic junction with success rates comparable to those of conventional laparoscopic and open pyeloplasty.

Classical dismembered as well as nondismembered pyeloplasty might prove impossible or very difficult not only in cases of diminutive or intrarenal pelvis but also if a severe fibrosis around the renal pelvis is at hand. In such cases, ureterocalicostomy can solve the problem. Traditionally, this has been performed with open surgery, but recently, Korets *et al.* [27] described the first case of robotic-assisted laparoscopic ureterocalicostomy with intraoperative nephroscopy. The procedure was uneventful and successful [27]. The latter study was preceded by another study by Gill *et al.* [28], some years ago, presenting their initial experience of laparoscopic ureterocalicostomy on two patients, one of whom succeeded and the other failed.

Apart from pyeloplasty, other ureteral reconstructive procedures have been performed with laparoscopics or robotics. Mufarrij *et al.* [29] reported on various robotic reconstructions in the upper urinary tract in 63 patients during a period of 4 years, including a few cases of ureteroureterostomy and ureteral reimplantation. Across all cases, mean blood loss was 125 ml, mean operative time was 244.8 min and mean length of stay was 2.8 days. The rate of radiographic and symptomatic improvement was 97.3 and 100%, respectively. Uberoi *et al.* [30] presented their applied techniques and experience on robot-assisted laparoscopic distal ureterectomy and ureteral reimplantation with psoas hitch on a patient diagnosed with carcinoma of the ureter. Postoperative course and short-term follow-up was uneventful [30]. According to very recent and preliminary results on few patients, robotics and traditional laparoscopy-assisted technique may in fact also be useful even in cases of intestinal replacement of the ureter. Wagner *et al.* [31] reported on a patient with a solitary kidney, cysteine stones and recurrent ureteral strictures who underwent robot-assisted laparoscopic ureterectomy with ileal ureter formation and with a good patency after 4 years of follow-up, and Castillo *et al.* [32] used laparoscopy-assisted technique for ileal substitution in two patients suffering from extensive ureteral stenosis after stone disease management.

Apart from these reconstructive procedures, robotic ureterolysis has been put forward as an option for the treatment of retroperitoneal fibrosis. Mufarrij *et al.* [33] performed robot-assisted ureterolysis, retroperitoneal biopsy and ureteral omental wrapping on five consecutive patients, all of whom have remained free of obstruction since surgery. Quite consistent with these findings, Stifelman *et al.* [34] recently reported on laparoscopic ureterolysis with or without robotic assistance on 15 renal units in 10 patients, after which almost 90% of all renal units were unobstructed on imaging after a mean follow-up of 15.6 months. Srinivasan *et al.* [35] compared laparoscopic and open ureterolysis with quite similar outcome between the two groups; however, conversion to open surgery was required in 17.6% of the patients in the laparoscopic ureterolysis cohort.

Transureteroureterostomy

There are certain conditions that might preclude the execution of traditional ureteric reconstruction, with or without the assistance of laparoscopy or robotics. For example, extensive resection of a cancer-infiltrated ureter might be necessary in order to maintain curative intent. In such cases, techniques such as the psoas hitch or the Boari flap might be impossible due to a thickening of the bladder wall, for example, after previous radiation treatment. One can argue that this would be an ideal case for ileal ureteral replacement; however, prior radiation or concomitant inflammatory bowel disease can make this treatment strategy unattractive as well. In such cases, transureteroureterostomy may be contemplated. The use of this technique dates back to the 1930s [36] but was popularized some 30 years later [37]; however, significant adverse effects were reported [38,39]. Throughout the years, there has been a sound reluctance amongst reconstructive surgeons to perform transureteroureterostomy, a technique which in fact jeopardizes the healthy contralateral side.

In a recent study, Joung *et al.* [40•] presented a series of 28 patients subjected to transureteroureterostomy for ureteral reconstruction during surgery for a nonurologic pelvic malignancy, comparing them with 17 patients reconstructed with end-to-end ureteroureterostomy or ureteroneocystostomy. No differences in complication rates were observed between the two groups, and the authors concluded that transureteroureterostomy could be a preferred method in patients requiring partial cystectomy or in those who have undergone prior surgery or radiotherapy.

Conclusion

Many of the techniques for ureteric reconstruction and replacement have remained unaltered throughout the years; however, there are certain interesting novelties emerging in this field of reconstructive surgery. The ureteric replacement with bowel has recently been carefully assessed by several authors, and the results are quite impressive. However, complication rates in these recent reports are still appearing significantly high, even in experienced hands, perhaps making such reconstructive techniques salvage procedures only to be chosen when more conservative surgical measures, not requiring intestinal incorporation in the urinary tract, have been ruled out.

In recent years, the literature has been generously endowed with reports on laparoscopic and robotic-assisted ureteral repair. Outcomes appear to be very promising, allowing for a faster recovery and shorter hospital stay for the patient. Rather long learning curves for laparoscopy, and considerable initial expenses for robotic-assisted surgery, are factors that must be taken into consideration. For robotics, a lack of tactile quality might also be a drawback, perhaps only being an initial problem, sufficiently compensated for by three-dimensional vision, good precision and the elimination of tremor in the narrow operating field.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

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Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 619–620).

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