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REVIEW

Techniques to resect the distal ureter in robotic/laparoscopic nephroureterectomy

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Abstract Treatment of clinically-organ confined high grade urothelial carcinoma of the upper tract has historically comprised open nephroureterectomy, with the distal ureter and bladder cuff mobilized through a separate open pelvic incision. To decrease morbidity, urologists have increasingly adopted laparoscopy and robotics in performing nephroureterectomy. In many published series of laparoscopic nephroureterectomy, the distal ureter and bladder cuff are detached from the bladder endoscopically by a variation of the "pluck" technique, with the resulting bladder defect left to heal by prolonged indwelling urethral catheter drainage. While the distal ureter and bladder cuff can be excised laparoscopically, it does require advanced laparoscopic skills. With the wrist articulation and stereoscopic vision in robotic surgery, robotic nephroureterectomy (RNU) and bladder cuff excision can be performed in antegrade fashion to mimic the open technique together with the ability to intracorporeally close the bladder defect in a watertight, mucosa to mucosa fashion after excising the bladder cuff. In this review, we discuss the published minimally invasive techniques in resecting the distal ureter and bladder cuff during laparoscopic and RNU.

1. Introduction

Upper tract urothelial carcinoma (UTUC) is an uncommon type of cancer. It comprises 5%–10% of malignancies arising from the kidney [1]. Similar to bladder cancer, UTUC has a high propensity for recurrence and progression. Prognosis is based on grade and stage. For clinically-organ confined disease, the standard of care for surgical management has been radical nephroureterectomy with excision of bladder cuff. Prior to the wide use of laparoscopy in urologic

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surgery, open nephroureterectomy (ONU) was commonly done with either one extended flank/abdominal incision or with two separate incisions (i.e., one for the nephrectomy and the other one for the distal ureterectomy). The bladder cuff was either excised by an extravesical or an intravesical approach.

In 1991, Clayman et al. [2] published their initial experience with laparoscopic nephroureterectomy (LNU). Compared to ONU, LNU has been shown to have decreased post-operative pain, decreased blood loss, and decreased recovery time [3]. In comparative studies, LNU also offered similar oncologic outcomes [3].

While the nephrectomy part of the case is relatively straightforward, the management of the distal ureter and the bladder cuff has been a source of controversy for at least the past two decades. This is, in part, due to the advanced laparoscopic skills required to mobilize the distal ureter to the level of the bladder and reconstruct the bladder defect with laparoscopic suturing after excising the bladder cuff. Many of the earlier LNU literature advocate endoscopic management of the distal ureter, especially as it pertains to the intramural ureter and the ureteral orifice. This is otherwise known as the "pluck" technique.

With the introduction of robot-assisted laparoscopic surgery, the learning curve to performing distal ureterectomy and bladder cuff excision has been mitigated with the increased magnification, 3-dimension vision, and 7 degrees of freedom offered by the da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA). The more recent robotic literature on nephroureterectomy describe extravesical techniques in performing dissection of the distal ureter with concomitant bladder cuff excision, as one would perform in replicating the open approach. In this review, we discuss the different published techniques in the management of the distal ureter during nephroureterectomy and present the pros and cons of each technique.

2. Endoscopic management of the ureter

2.1. Variations of the "pluck" technique

In 1952, McDonald et al. [4] described their technique of endoscopic resection of the ureteral orifice into the perivesical fat. After freeing the ureter endoscopically, the nephroureterectomy was performed through a single flank incision. The ureter was placed on gentle traction to pull it away from the bladder (hence the term "pluck"). The bladder defect was not closed. This technique was not widely adopted in open cases, as there was concern of increased locoregional tumor recurrence with spillage of tumor cells from an unclamped ureter into the perivesical space during endoscopic resection of the ureter [5]. Although the bladder defect was not closed, there were no significant complications rates reported.

One main oncologic advantage of the pluck technique is the ability to minimize risk of continued drainage of cancer cells from a patent ureter during and after endoscopic resection. Many different options for ureteral occlusion have been developed, especially in the studies presenting results of LNU and hand-assisted LNU. These variations include suture ligation, fulguration of the ureteral lumen, occluding the ureteral lumen with a balloon, occluding the ureteral lumen with fibrin, or placement of a clip on the proximal ureter to prevent distal migration of UTUC cells.

In 1999, Gill et al. [6] published their technique of ligating the ureter transvesically with an ENDOLOOP ligature (Ethicon, Sommerville, NJ, USA). In this technique, two needlescopic ports were placed percutaneously into the bladder under cystoscopic guidance. The ENDOLOOP was placed through the port on the same side as the target ureteral orifice. A ureteral catheter was advanced through the ENDOLOOP and the ureteral orifice. With a Collins knife through the resectoscope, the bladder cuff, intramural ureter, and extravesical ureter (3—4 cm) were circumferentially mobilized to the extravesical fat. After removing the ureteral catheter, the ENDOLOOP was tied down around the ureter to occlude the lumen. The ureteral orifice was also fulgurated. After completion of the endoscopic procedure, the authors repositioned the patient in flank position for retroperitoneal LNU. The benefit to this approach is ligation of the distal segment to prevent tumor spillage. Contemporary trends have moved towards placement of clip on the ureter via peritoneal approach to prevent distal tumor migration.

Agarwal et al. [7] also described a technique in occluding the ureter with the ENDOLOOP. In their method, which was done transurethrally, the authors mobilized the ureteral orifice with the Collins knife without detaching the ureter or exposing the perivesical fat prior to ligation of the ureteral stump with the ENDOLOOP. After the stump was ligated, they then further mobilized the ureter more proximally to the perivesical fat to detach the ureter from the bladder.

Wong and Leveillee [8] described a hand-assisted LNU approach in which they first proceed with nephrectomy. Prior to dissecting out the kidney, the ureter was clipped. The main advantage of this approach is that the kidney is able to be mobilized and hilum controlled with a larger working space, and then after the kidney was mobilized, the ureter was mobilized to the intramural hiatus. With the laparoscopist maintaining tension on the ureter, the cystoscopist excised the bladder and intramural ureter with a Collins knife. The main disadvantage to this approach is that a second monitor and camera are required to resect the distal ureter from below while the pneumoperitoneum is maintained. The bladder defect was not closed. A non-hand-assisted LNU approach was similarly described by Tan et al. [9]. The benefit to this approach included the direct visualization of perivesical fat upon dissection of the distal ureter, with confirmation that the entire transmural ureter was free, minimizing the chances of local recurrence.

Vardi et al. [10] described a similar hand-assisted LNU approach in which they also clipped the ureter prior to completing the nephrectomy. Instead of using the resectoscope, they used a 5 Fr electrode (on cutting current) through a flexible cystoscope to resect the bladder cuff.

In Zou et al. [11], the authors instilled carbon dioxide gas into the bladder to establish a pneumovesicum. They excised a bladder cuff around the ureteral orifice with a Collins knife and mobilized the ureter to the perivesical fat. They then placed a 10 mm suprapubic trocar into the