Robot-assisted laparoscopic continent cutaneous urinary diversion in a single-center study; surgical technique and outcomes

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Research Article

Keywords: Continent Urinary diversion, Robotic surgery, Mitrofanoff procedure, Laparoscopy, Neurogenic bladder

Posted Date: November 14th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-3575709/v1

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Additional Declarations: No competing interests reported.
Abstract

Introduction:

Robot assisted laparoscopic cutaneous continent urinary diversion (RALCCUD) has been shown to be feasible; however, data on clinical outcomes in adults are lacking.

Materials & Methods:

We conducted a retrospective study of all adults who underwent RALCCUD between 2017 and 2022 at a single tertiary reference center. Participant characteristics, clinical information and perioperative outcomes were recorded. All participants underwent pre and postoperative urodynamic evaluations.

Functional outcomes were evaluated at 3 months, then yearly. Continence was defined as no stomal or urethral leakage.

Results:

Twelve patients, mostly women (n=11), median (IQR) age 47.4 (19-57) years underwent RALCCUD (4 Mitrofanoff, 4 Yang-Monti and 4 Casale). The main indication for surgery was inability to perform intermittent self-catheterization through the native urethra. Eleven patients (92%) had neurogenic lower urinary tract disease caused by spinal cord injury or spinal dysraphism. Median (IQR) operative time was 313 (285-367) min. Four patients (33%) underwent concomitant procedures: 3 supra-trigonal cystectomy with augmentation cystoplasty and 1 artificial urinary sphincter. No conversions to an open approach were required. Median (IQR) follow-up was 42.9 (34-53) months. One early postoperative complication occurred (Clavien grade III). The late postoperative complication rate was 17%, with 3 complications occurring in 2 patients.

At the last follow up, all patients could self-catheterize through the tube, and the stomal and urethral continence rate was 100%.

Conclusion:

RALCCUD is feasible and safe in adults, with a high rate of stomal and urethral continence and a low complication rate.

Introduction

Guidelines for the treatment of people with neurogenic low urinary tract dysfunction (NLUTD) include the management of neurogenic detrusor overactivity (NDO) combined with intermittent self-catheterization (ISC)\(^1\). This treatment strategy aims to protect the upper urinary tract and maintain urinary continence by ensuring a low-pressure bladder reservoir\(^1\)\(^-\)\(^3\). However, some people who require ISC are unable to perform it through the native urethra because of upper-limb disability, difficulty reaching or finding the urethra, or urethral destruction. Cutaneous continent urinary diversion (CCUD) (Mitrofanoff\(^4\), Yang-Monti\(^5\) or Casale\(^6\) procedures) can be offered to such individuals to allow ISC. Several case-series studies have reported good long-term results from this technique in children\(^7\) and adults\(^8\).

Robot assisted laparoscopic cutaneous continent urinary diversion (RALCCUD) was developed in the 2000s\(^9\) and provides the advantage of shorter length of hospital stay compared to the open approach\(^10\). Several studies with long-term follow-ups have demonstrated the feasibility and efficacy of (RALCCUD) in children\(^11\),\(^12\), but only a few small case-series have been published in adults\(^13\),\(^14\).

The aim of the current study was to report the perioperative outcome and preliminary functional results using the RALCCUD technique in terms of continence, catheterization and repeat surgery.

If concomitant AC was performed, a supra-trigonal cystectomy (SC) was performed with preservation of the posterolateral bladder-wall flap in which the efferent tube could be implanted according to the politano-leadbetter principle, as previously published, using an open approach\(^18\),\(^19\).

Then the AC was sutured to the remaining bladder using 3/0 V-Lock running sutures.

The watertightness was checked by filling the bladder with 180 mL saline solution.

Stoma

The stoma was always placed at the umbilical level.

Before the anastomosis between the channel and the skin was performed, the bladder was sutured to the anterior abdominal wall with interrupted 2/0 sutures to avoid kinking of the channel and to minimize the extravesical portion as described for the open technique\(^20\).
The distal efferent tube was sutured to the skin with a V-shaped skin ap using interrupted 4/0 polydioxanone sutures. A 14Fr Foley catheter was then placed in the tube as well as in the urethra, for 21 days.

**Materials & Methods**

We conducted a single center, retrospective, case-series study of individuals who underwent RALCCUD in our department between 2017 and 2022. Ethical approval was granted by our local ethical committee the Institutional Ethical and Clinical Research at Nantes Université (Groupe Nantais d'Ethique dans le Domaine de la Santé) review board (Nantes, 2022) number “AVIS 22-3-170”.

Indications for the surgery were the inability to perform ISC through the urethra because of difficulty reaching or finding the urethra. Inclusion criteria for the study were age at least 15 years old and with a post-surgical follow-up of at least 3 months.

Before surgery, all individuals underwent an assessment by a multidisciplinary team that included at least a urologist, a physical medicine and rehabilitation doctor and, if necessary, an occupational therapist. The ability to hold a catheter and to self-catheterize through an abdominal stoma was assessed during a short hospital stay prior to surgery.

Individuals with traumatic spinal cord injury underwent MRI to rule out the presence of syringomyelia, which may be a contra-indication to the laparoscopic approach.

An assessment was performed preoperatively, at 3 months post-operatively and then yearly. The assessment included stomal and urethral continence, satisfaction, renal function and urodynamic function, outcomes and complications.

The primary outcome was continence status at the last follow-up. Continence was defined as no leakage (no pad) from either the urethra or the stoma without the need for secondary incontinence surgery after RALCCUD. The secondary outcomes were the rate of clinically significant post-operative complications (≥ grade 3 on the Clavien Dindo classification), classed as early (0–30 days post-operative) or late (> 30 days post-operative), and the rate of stomal complications requiring reintervention. The stomal complications requiring reintervention included stenosis, false route and incontinence after excluding other causes such as bladder overactivity.

**Statistical analysis:**

Continuous variables are expressed as medians and interquartile ranges (IQRs; 25th and 75th percentiles), and categorical variables as numbers and percentages. MannWhitney test or Student’s t-test was used to compare continuous variables according to normal distribution (Shapiro–Wilk's test) and chi-square or Fischer’s exact test for categorical variables. A p < 0.05 was considered significant. SAS software (version 9.4, NC, USA) was used.

**Surgical Technique**

All the procedures were performed by two surgeons.

The patient was placed in a modified lithotomy position with 25° of Trendelenburg to shift the bowel away from the pelvis. An 18Fr Foley catheter was placed in the bladder.

The camera port (8 mm) was placed intraperitoneally via an open laparoscopy approach under the umbilicus, and pneumoperitoneum was established with 12 mmHg insufflation pressure. An 8-mm robotic port was placed on each side of the camera port and a fourth robotic port was placed in the right iliac fossa at the same level. The ports were placed at least 8 cm apart. An additional 12-mm port was inserted in the left iliac fossa for the assistant. After trocar placement, the robot (four-arm Da Vinci Xi Surgical System®, Intuitive Surgical, Inc., Sunnyvale, CA, USA) was docked.

Bladder mobilization:

The bladder was freed from the peritoneum and mobilized by sectioning the urachus and the two umbilical arteries. It is critical to ensure that the bladder is adequately mobilized and that it can easily be brought to the anterior abdominal wall near the camera port.

Catheterisable tube preparation

The preferred choice for tube formation was the appendix. It was identified after mobilizing the caecum, from which it was then separated with care taken to preserve the blood supply.
Then, the length of the tube and the anatomical possibility to reach the planned stoma location were verified. A key issue for RALCCUD is an accurate evaluation of the distance between the implantation of the conduit in the bladder and the stomal anastomosis.

The tip of the appendix was sectioned, and a 14 Fr feeding-tube was introduced to verify the patency of the whole appendix.

In case of previous appendicectomy, or an unusable appendix, it is possible to use a retubularized tube, according to the Yang-Monti technique. For this, a 3/0 polyglotone suture was placed on the ileum 30 cm from the ileocecal valve. The robot was undocked and performed a 4 cm incision below the umbilical incision. A 2 cm intestinal segment located 30 cm from the ileocecal valve was isolated extracorporeally to construct a retubularized tube.

Then the tube was reintroduced in the abdomen and the robot was docked to carry on the surgery intraperitoneally. If the distance between the bladder and abdominal wall was long, a tube was prepared according to the Casale Principle, after isolation of an ileal segment of 3.5 cm in length.

In case of concomitant augmentation cystoplasty (AC), a 30 cm ileal segment was isolated at 30 cm from the ileocecal valve at the same time.

Anti-reflux anastomosis

The tube was always implanted in the posterior bladder wall. If concomitant AC was not performed, the tube was implanted according to the Lich-Gregoir anti-reflux principle. The bladder was filled with 300 mL of saline solution. The posterior wall of the bladder was opened sagittally with preservation of the bladder mucosa. Each side of the detrusor muscle was suspended to the anterior abdominal wall using a 3/0 polyglactin suture to provide adequate exposure. The catheterisable channel was sutured to the bladder mucosa with interrupted 5/0 polydioxanone sutures and the detrusor was closed with 3/0 polyglactin to create a submucosal anti-reflux mechanism at least 4 cm long.

Results

Patient characteristics and perioperative data

Patient characteristics and outcomes are shown in Table 1.

<table>
<thead>
<tr>
<th>Case number</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Diagnosis</th>
<th>Type of CCUD</th>
<th>Concomitant procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22</td>
<td>Female</td>
<td>NLUTD and BPS</td>
<td>Yang-Monti ileal conduit</td>
<td>SC and AC</td>
</tr>
<tr>
<td>2</td>
<td>17</td>
<td>Female</td>
<td>Spina bifida L2</td>
<td>Mitrofanoff conduit</td>
<td>SC and AC</td>
</tr>
<tr>
<td>3</td>
<td>51</td>
<td>Female</td>
<td>NLUTD due to SCI C5</td>
<td>Yang-Monti modified Casale ileal conduit</td>
<td>SC and AC</td>
</tr>
<tr>
<td>4</td>
<td>67</td>
<td>Female</td>
<td>NLUTD due to SCI T10</td>
<td>Yang-Monti ileal conduit</td>
<td>AUS</td>
</tr>
<tr>
<td>5</td>
<td>52</td>
<td>Female</td>
<td>NLUTD due to SCI T9</td>
<td>Yang-Monti modified Casale ileal conduit</td>
<td>-</td>
</tr>
<tr>
<td>6</td>
<td>16</td>
<td>Female</td>
<td>NLUTD due to SCI C6</td>
<td>Mitrofanoff conduit</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>Female</td>
<td>NLUTD due to SCI C3</td>
<td>Mitrofanoff conduit</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>73</td>
<td>Female</td>
<td>NLUTD due to SCI T4</td>
<td>Yang-Monti modified Casale ileal conduit</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>67</td>
<td>Female</td>
<td>NLUTD due to SCI C7</td>
<td>Yang-Monti ileal conduit</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>55</td>
<td>Male</td>
<td>NLUTD due to SCI T12</td>
<td>Yang-Monti ileal conduit</td>
<td>-</td>
</tr>
<tr>
<td>11</td>
<td>43</td>
<td>Female</td>
<td>NLUTD due to SCI C7</td>
<td>Yang-Monti modified Casale ileal conduit</td>
<td>-</td>
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<tr>
<td>12</td>
<td>18</td>
<td>Female</td>
<td>NLUTD due to SCI C5</td>
<td>Mitrofanoff conduit</td>
<td>-</td>
</tr>
</tbody>
</table>

Median Value (IQR) 47.4 (19;57.9)

Twelve patients were included; median (IQR) age was 47.4 (19.5–57.6) years (range 16–74 years), and 11 participants were female (92%). Eleven participants had NLUTD caused by spinal cord injury (SCI) or spinal dysraphism, and one had a history of bladder pain syndrome/interstitial cystitis (BPS/IC). None had renal insufficiency before or after the surgery.

Four participants underwent a concomitant procedure: 3 SC with AC for poor bladder compliance, refractory neurogenic detrusor overactivity (NDO) or refractory severe IC. One female with SCI was provided with an artificial urinary sphincter (AUS) for stress urinary incontinence related to neurogenic intrinsic sphincter deficiency.

Conversion to an open approach was not required for any participant. The median (IQR) operating time was 313 (285–367) min (range 224 to 643) and median (IQR) estimated blood loss was 100mL (100–150).

The median (IQR) length of hospital stay for the 12 patients was 8 (7–11) days and was 13 days (range 10 to 16) for those who underwent concomitant procedures (p > 0.05).

The median operating time was 635 (range to 392–643) min for the patients who underwent concomitant procedures (SC and AC or AUS) and was 300 min (range to 224–367) for those who did not (p = 0.03).

Post-operative complications
The median (IQR) follow-up duration was 42.9 (34-53.5) months (range 5 to 70.7).

The early and late complication rates were 8% (1/12) and 17% (2/12) respectively. The stomal complication rate was 17% (2/12) with a complication rate of 25% for Mitrofanoff, 25% for Casale conduit and 0% for Yang-Monti. Details of the complications are provided in Table 2. No complications were rated > grade 3 on the Clavien Dindo classification.

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### Table 2

<table>
<thead>
<tr>
<th>Case number</th>
<th>Age (years)</th>
<th>Sex</th>
<th>Etiology</th>
<th>Conduit</th>
<th>Type of complication</th>
<th>Clavien grade</th>
<th>Onset of complications (months)</th>
<th>Treatment</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>17</td>
<td>Female</td>
<td>Spina bifida L2</td>
<td>Mitrofanoff</td>
<td>Stomal stenosis &amp; false route</td>
<td>3</td>
<td>35</td>
<td>Endoscopic dilatation</td>
<td>ISC via stoma, continent</td>
</tr>
<tr>
<td>8</td>
<td>73</td>
<td>Female</td>
<td>NLUTD due to SCI T4</td>
<td>Yang-Monti modified Casale ileal conduit</td>
<td>Wound abscess</td>
<td>3</td>
<td>1</td>
<td>Surgical management</td>
<td>Healing of the wound</td>
</tr>
<tr>
<td>8</td>
<td>73</td>
<td>Female</td>
<td>NLUTD due to SCI T4</td>
<td>Yang-Monti modified Casale ileal conduit</td>
<td>Stomal incontinence</td>
<td>3</td>
<td>10</td>
<td>Polydimethylsiloxane endoscopic injection twice at the distal end of the conduit</td>
<td>ISC via stoma, continent</td>
</tr>
<tr>
<td>8</td>
<td>73</td>
<td>Female</td>
<td>NLUTD due to SCI T4</td>
<td>Yang-Monti modified Casale ileal conduit</td>
<td>Urethral incontinence</td>
<td>3</td>
<td>10</td>
<td>Peri-urethral balloons pro-ACT</td>
<td>ISC via stoma, continent</td>
</tr>
</tbody>
</table>


One participant (case 1) with a history of BPS/IC underwent a cystectomy with ileal conduit 34 months after RALCCUD because of refractory chronic pelvic pain. The participant was continent and had no catheterization difficulties before this reoperation.

Another participant (case 6) died from her initial disease (medullar glioblastoma) nearly 5 months after the surgery. No incontinence or catheterization difficulties were reported.

Functional results
The overall continence rate was 92% (11/12). The stomal continence rate was 92% (11/12). One participant (case 8) had stomal incontinence after insertion of a Casale conduit, which was treated by a bulking agent injection (Macroplastique® (Uroplasty) Laborie, Ontario, Canada). The urethral continence rate was 92% (11/12); the same participant (case 8) had urethral incontinence that was treated with a peri-urethral...
balloon (Adjustable Continence Therapy, ACT®) (Table 2). At the last follow-up, all participants reported stomal and urethral continence and performed ISC through the tube. No false passage or difficulty catheterizing the tube was reported.

The overall reoperation rate (including to treat complications and improve continence) was 33% (4/12) (Table 2). Only one stomal stenosis occurred at 35 months (case 2) and was managed by endoscopic dilatation.

No participants had renal insufficiency before or after the surgery.

The median (IQR) pre-operative urodynamic characteristics were a bladder capacity of 475 (300–500) mL, a urethral closure pressure of 55 (37.5–120) cmH2O and bladder pressure at end of the filling of 21 (19–27) cmH2O. At the last follow-up, the median (IQR) post-operative bladder capacity was 400 mL (350–500) with a bladder compliance > 20. The bladder capacity of the 3 participants with an AC increased up to 300 ml and bladder compliance was > 20 in all 3.

**Discussion**

This study showed that all 12 participants who underwent RALCCUD were continent at the last follow up. Two participants experienced stomal complications and none experienced complications > Clavien 3.

These data complete those from a study in children that found RALCCUD to be safe and comparable in terms of long-term functional outcomes with the results of traditional surgical procedures.

The arrival and development of robotic surgery was a watershed moment in the world of laparoscopic surgery. It led to the expansion of the laparoscopic approach to complex neuro-urology surgeries. Since the first RALCCUD reported in 2004, the technique has been developed and standardized in both children and adults. Although robotic technology has been adopted for many urologic procedures in adults, only a few studies of RALCCUD have been performed in adults.

The median operating time was 313 min. This is comparable with other reports in adults and children; however, the range is very large (224 to 643 min). We suggest 3 explanations for this. First, when no concomitant technique is performed, the standardization of the technique makes it short in duration. Galanski et al showed that operative time reduced from around 500 min to 300 min after 10 years of experience.

Second, RALCCUD associated with a AC is a real challenge and requires a much longer operating time. The third reason is that a Casale or Yang-Monti conduit was used for most participants (66%), requiring an ileal conduit to be used to create the conduit.

In most studies, Casale or Yang-Monti conduits were little used. In our series, the appendix was used in only 33% of participants (4/12). Our results suggest that the creation of a Casale or a Yang-Monti conduit using robotic assistance is feasible and safe. Furthermore, the short-term functional results were very good. Indeed, the continence rate was high and the complications rate was low for all tube-types.

In our series, the stomal continence rate without repeat surgery was very high (92%). It was higher than the 60% (6/10 participants) rate reported by Lecoanet et al but was similar to rates in other tertiary centers of adult or pediatric urology. We chose to implant the channel posteriorly on the bladder to reproduce the technique initially described by Mitrofanoff. Although there are no published comparisons of posterior and anterior channels in adults, studies in children suggest that anterior and posterior channels have similar revision rates. The management of incontinent CCUD with endoscopic injection of submucosal bulking agents is well known to provide good results. Recently, Riachy et al found an 86% success rate (either achievement of continence or improvement in continence) in a retrospective study.

The high rate of urethral continence (92%) may have resulted from good pre-operative screening and management. In our center, the intervention was always performed in the neuro-urology unit with urodynamic assessment. We believe that eligibility screening by a multidisciplinary team including a urologist and rehab physician is key to the success of the intervention.

The rate of complications was low (17%) and was lower than that found in other recent studies in tertiary centers for open, laparoscopic or robot-assisted surgery. In their comparative study of continent, cutaneous, catheterizable channels, Galanski et al reported a complication rate of 43% and 38% for open and robot-assisted surgery respectively. Of note, that study was done in children, in whom complications are managed differently from adults.

Only one stomal stenosis occurred during the follow-up period, and it was managed by endoscopic dilatation. This low rate of stomal stenosis could be attributed to the systematic use of the V-shaped skin flap to enlarge the circumference of the stoma as previously described.
This study has several limitations. The first is that it was a retrospective, single center study. However, to our knowledge, it is one of the largest studies of RALCCUD in adults to date with 12 individuals included. So far, only 2 retrospective case-series have been published, with follow-ups of less than 24 months\textsuperscript{13,14}. The second limitation is the median follow-up of only 40.3 months; however, in a retrospective study of 119 stomas, Jacobson et al\textsuperscript{23} found that stomal stenosis, false passage and first complications occurred within a mean 24.2 months. However, since complications can still occur more than 10 years after the surgery\textsuperscript{7}, long-term follow-up is required.

**Conclusion**

RALCCUD with Mitrofanoff and Yang-Monti conduits with or without AC seems safe and feasible in adults with NLUTD who are unable to self-catheterize through the native urethra. It seems to provide a very high short-term rate of stomal and urethral continence with a low rate of complications. Multicenter, prospective studies are now required to confirm these results and to determine the place of RALCCUD in the management of these issues.

**Abbreviations**

AC= Augmentation Cystoplasty  
AUS= Artificial Urinary Sphincter  
BPS/IC= Bladder Pain Syndrome/Interstitial Cystitis  
CCUD= Continent Cutaneous Urinary Diversion  
ISC= Intermittent self-catheterization  
NDO= Neurogenic Detrusor Overactivity  
NLUTD= Neurogenic Low Urinary Tract Dysfunction  
RALCCUD= Robot Assisted Laparoscopic Continent Cutaneous Urinary Diversion  
SC= Supratrigonal Cystectomy  
SCI= Spinal Cord Injury

**Declarations**

**Data Statement:**

The data that support the findings of this study are not openly available due to reasons of sensitivity and are available from the corresponding author upon reasonable request. Data are located in controlled access data storage at Nantes Université, Nantes, France.

**Funding Statement:**

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

**Conflict of interest:**

The authors declare that they have no conflict of interest.

**Ethical Compliance:**

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Our study was approved by our local ethical committee the Institutional Ethical and Clinical Research at Nantes Université (Groupe Nantais d’Ethique dans le Domaine de la Santé) review board (Nantes, 2022) number “AVIS 22-3-170”.

**Patient consent statement:**

Informed consent was obtained from all individual participants included in the study.
Permission to reproduce material from other sources:

We have not used materials from other sources.

Clinical trial registration:

It is a retrospective study registered at our local ethical committee at Nantes Université “Groupe Nantais d’Ethique dans le Domaine de la Santé” (GNEDS) (AVIS 22-3-170).

Author Contributions:

T. Loubersac: Protocol/project development, Data collection and management, Data analysis, Manuscript writing/editing; E. Lavallée: Data analysis, Manuscript writing/editing; B. Reiss: Data collection and management, Manuscript writing/editing; MD. Leclair : Manuscript writing/editing ; P. Kieny: Data collection and management, Data analysis, Manuscript writing/editing ; M. Le Fort : Manuscript writing/editing, L. Lenormand: Manuscript writing/editing ; J. Rigaud : Manuscript writing/editing ; B. Perrouin – Verbe: Data collection and management, Manuscript writing/editing ; C. Lefevre: Manuscript writing/editing; M.A. Perrouin-Verbe Protocol/project development, Data analysis, Manuscript writing/editing

References


**Supplementary Files**

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- RALCCUDTable1JRS07112023.docx