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EUROPEAN UROLOGY XXX (2012) XXX–XXX

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Surgery in Motion

Robotic Intracorporeal Orthotopic Ileal Neobladder: Replicating Open Surgical Principles 1

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Following robotic radical cystectomy and extended lymphadenectomy, a technique for robot-assisted intracorporeal ileal neobladder can be performed in a standardized, time-efficient, and reproducible fashion, while preserving open surgical principles, to optimize functional outcomes and minimize perioperative morbidity.

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Robotic Intracorporeal Orthotopic Ileal Neobladder: Replicating Open Surgical Principles

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Abstract

Background: Robotic radical cystectomy (RC) for cancer is beginning to gain wider acceptance. Yet, the concomitant urinary diversion is typically performed extracorporeally at most centers, primarily because intracorporeal diversion is perceived as technically complex and arduous. Previous reports on robotic, intracorporeal, orthotopic neobladder may not have fully replicated established open principles of reservoir configuration, leading to concerns about long-term functional outcomes.
Objective: To illustrate step-by-step our technique for robotic, intracorporeal, orthotopic, ileal neobladder, urinary diversion with strict adherence to open surgical tenets.
Design, setting, and participants: From July 2010 to May 2012, 24 patients underwent robotic intracorporeal neobladder at a single tertiary cancer center. This report presents data on patients with a minimum of 3-mo follow-up ($n = 8$).
Surgical procedure: We performed robotic RC, extended lymphadenectomy to the inferior mesenteric artery, and complete intracorporeal diversion. Our surgical technique is demonstrated in the accompanying video.
Outcome measurements and statistical analysis: Baseline demographics, pathology data, 90-d complications, and functional outcomes were assessed and compared with patients undergoing intracorporeal ileal conduit diversion ($n = 7$).
Results and limitations: Robotic intracorporeal urinary diversion was successfully performed in 15 patients (neobladder: 8 patients, ileal conduit: 7 patients) with a minimum 90-d follow-up. Median age and body mass index were 68 yr and 27 kg/m^2, respectively. In the neobladder cohort, median estimated blood loss was 225 ml (range: 100–700 ml), median time to regular diet was 5 d (range: 4–10 d), median hospital stay was 8 d (range: 5–27 d), and 30- and 90-d complications were Clavien grade 1–2 ($n = 5$ and 0), Clavien grade 3–5 ($n = 2$ and 1), respectively. This study is limited by small sample size and short follow-up period.
Conclusions: An intracorporeal technique of robot-assisted orthotopic neobladder and ileal conduit is presented, wherein established open principles are diligently preserved. This step-wise approach is demonstrated to help shorten the learning curve of other surgeons contemplating robotic intracorporeal urinary diversion.

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1. Introduction

The benchmark of surgical treatment for muscle-invasive and high-risk recurrent or refractory non–muscle-invasive urothelial carcinoma of the bladder is open radical cystectomy (RC), extended lymphadenectomy, and urinary diversion. The procedure remains complex, with significant morbidity, relatively long convalescence time, and negative nutritional balance in a typically older patient population [1,2].

In the past decade, laparoscopic RC and, recently, robotic RC have emerged as minimally invasive alternatives to open RC in an effort to reduce morbidity and enhance recovery. Data from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample inform that robotic RC comprised 13.3% of all RC surgeries in the United States in 2009 [3]. We have noted similar trends at our tertiary cancer center [4]. Early to intermediate perioperative and oncologic outcomes of robotic RC and lymphadenectomy are promising and appear comparable to open surgery [5–7].

Despite the increasing use of robotic RC [8,9], the majority of centers perform extracorporeal urinary diversion due to perceived difficulties with intracorporeal bowel reconstruction and concerns about time efficiency compared to open surgery. As experience in robotic surgery has expanded, a few reports of intracorporeal orthotopic neobladder have recently emerged [10–12]. To improve efficiency and decrease operative time, several modifications to standard open pouch configurations have been used. One modification has been the use of laparoscopic staplers using nonabsorbable titanium staples instead of absorbable sutures [10]. Another is using a shorter length of bowel and a modified pouch configuration that may not conform to a sphere, unlike that created during open surgery [11,13]. Such technical circumventions have raised concerns regarding long-term efficacy.

We present a detailed step-by-step description of our technique of robotic, intracorporeal, orthotopic, ileal neobladder that adheres to the established dimensions and configuration of the Studer orthotopic neobladder as performed by open surgery at our institution. We describe technical challenges and tips to optimize performance of this complex operation.

2. Methods and patients

Robotic RC, high-extended lymphadenectomy to the inferior mesenteric artery, and intracorporeal, orthotopic, ileal neobladder was performed in 24 patients with bladder cancer. From this cohort, data are reported on eight patients who had completed 90-d follow-up. Data are also presented for seven patients undergoing robotic, intracorporeal, ileal conduit diversion for comparison. All data were entered prospectively into an institutional review board–approved database and queried retrospectively.

Our inclusion criteria for robotic RC are similar to those for open cystectomy. We offer robotic RC to obese patients (body mass index [BMI] ≤40), those who have had prior pelvic surgery and/or prior pelvic radiation, and following neoadjuvant chemotherapy in patients with locally advanced disease and/or low-volume nodal involvement.

Our technique of robotic RC and high-extended lymphadenectomy was described recently [14]. In this paper, we focus on the robotic, intracorporeal, urinary diversion.

2.1. Positioning

In steep Trendelenburg position, a six-port transperitoneal approach is used (Fig. 1). In contrast to robotic prostatectomy, all ports are moved cephalad during RC, wherein the camera port is positioned approximately two fingerbreadths above the umbilicus with the right and left working ports placed at the level of the umbilicus. Cephalad port placement facilitates proximal ureteral mobilization, nodal dissection along the infrarenal aorta/vena cava, and small bowel manipulation during intracorporeal diversion.

2.2. Bowel isolation and reanastomosis

To construct the neobladder, we select approximately 60 cm of distal ileum (44 cm for the pouch, 16 cm for the chimney) about 15 cm proximal to the ileocecal junction (Fig. 2). A Penrose drain, premarked at 10, 15, and 22 cm, is inserted intra-abdominally to facilitate measurement of bowel segment length for pouch creation. Atraumatic Cardiere forceps (Intuitive Surgical Inc, Sunnyvale, CA, USA) are used in the right and left robotic arms for bowel manipulation. Distal transection of ileum is performed with a 60-mm laparoscopic stapler (Echelon Stapler; Ethicon Endo-Surgery Inc, Cincinnati, OH, USA) via the 15-mm lateral assistant port. The initial tissue load (3.5-mm thickness) transects small bowel and divides part of the adjacent mesentery. Major mesenteric blood vessels can be identified with fluorescence-enhanced imaging using intravenous indigo-cyanine green (Fig. 3). The mesenteric window is further developed using electrocautery or an additional vascular stapler load (2.5-mm thickness). The transected bowel segment (toward the cecum) is marked with a violet-dyed 3-0 Vicryl suture. With the Penrose drain ruler, 60 cm of ileum is measured. Using undyed sutures,

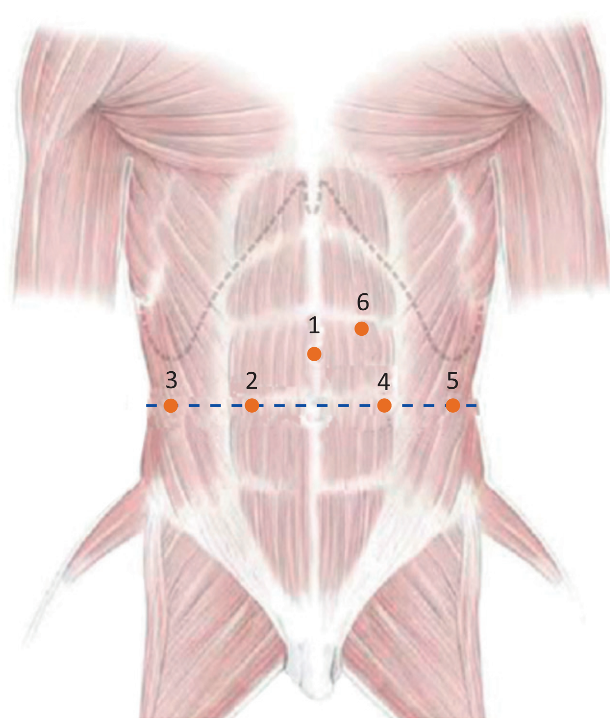

Fig. 1 – Trocar configuration. The camera port and three robotic ports were placed at positions 1, 2, 3, and 4, respectively. Additionally, 12-mm and 15-mm assistant ports were used at positions 5 and 6.

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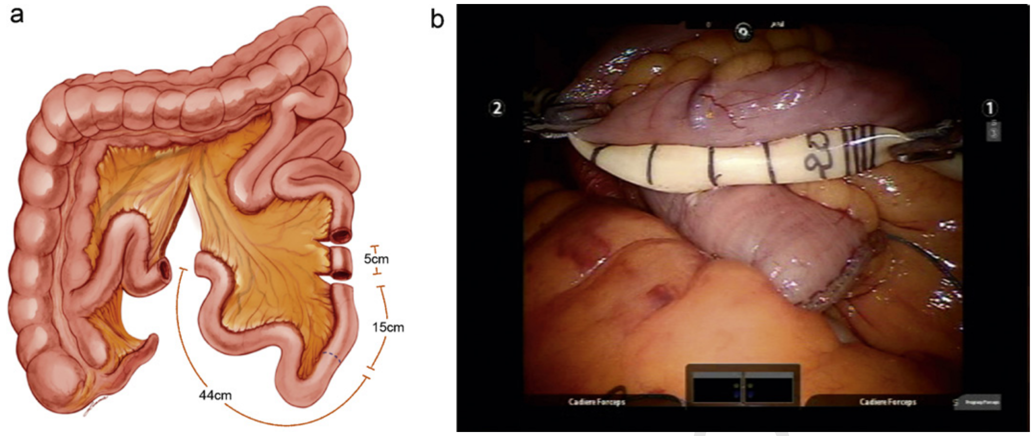

Fig. 2 – (a) Dimensions of harvested bowel segments. (b) Atraumatic Cardiere forceps and a marked Penrose drain were used to measure the ileal segment.

the ileal segment is marked at 22 cm (denoting the apex of the posterior plate) and 44 cm (denoting beginning of the afferent limb). After proximal division of the ileal segment, another violet-dyed 3-0 Vicryl suture is placed to mark the proximal transected ileum. Using the violet sutures for traction, bowel continuity is re-established with a standard side-to-side ileoileal anastomosis using a 60-mm laparoscopic tissue stapler load to anastomose the adjacent antimesenteric ileal walls. The open ends of ileum are closed with a tissue stapler load deployed transversely to finish the side-to-side anastomosis. The ileoileal anastomosis is performed cephalad to the excluded ileal segment, keeping the isolated ileal segment caudal to the mesentery.

2.3. Configuration of orthotopic neobladder

Dimensions of the neobladder are maintained as described by Studer [15] and performed by open surgery at our institution. The undyed marking suture at 22 cm from the distal end of excluded ileum is grasped by the fourth robotic arm and retracted into the pelvis, which helps to symmetrically align two 22-cm ileal segments adjacent to each other (Fig. 4a). The additional 15 cm of ileum is used for the afferent limb.

The 44 cm of ileum, comprising the neobladder, is detubularized with the incision biased toward the mesenteric edge. We insert a 24F chest tube to expedite detubularization (Fig. 4b). The apposing edges of the posterior wall of the neobladder are aligned with several 2-0 absorbable interrupted sutures. Subsequently, the posterior wall of the neobladder is constructed in a watertight manner (Fig. 5a) with 2-0 running barbed sutures (V-loc; Covidien, New Haven, CT, USA).

Once the posterior plate is complete, a 3-0 barbed suture is placed at the midpoint of the right side of the posterior plate at the site of the anticipated urethroileal anastomosis. The suture is passed in a Figure 8 configuration at the mesenteric border. The posterior plate is then rotated 90° counterclockwise with caudal traction applied to the 3-0 suture to set up the urethroileal anastomosis (Fig. 5b). The 3-0 barbed suture is passed through the distal Denonvilliers' fascia, adjacent to the rectourethralis muscle, to reduce tension on the urethroileal anastomosis.

2.4. Urethroileal anastomosis and anterior pouch closure

The urethroileal anastomosis is performed in a running fashion with a double-armed 3-0 Monocryl suture on an RB-1 needle (Ethicon Inc, Somerville, NJ, USA) starting at the 6 o'clock position. The anastomosis is completed over a 22F Couvelaire catheter.

With the posterior plate anastomosed to the urethra, secondary folding is accomplished with anterior closure of the pouch. Cross-folding is performed by placing a midpoint horizontal mattress suture that divides the anterior suture line into two equal halves and aligns the edges for suturing. The anterior wall of the neobladder is closed with running 2-0 barbed suture (Fig. 5b). A small opening is left in the anterior suture line to allow passage of bilateral ileoureteral stents.

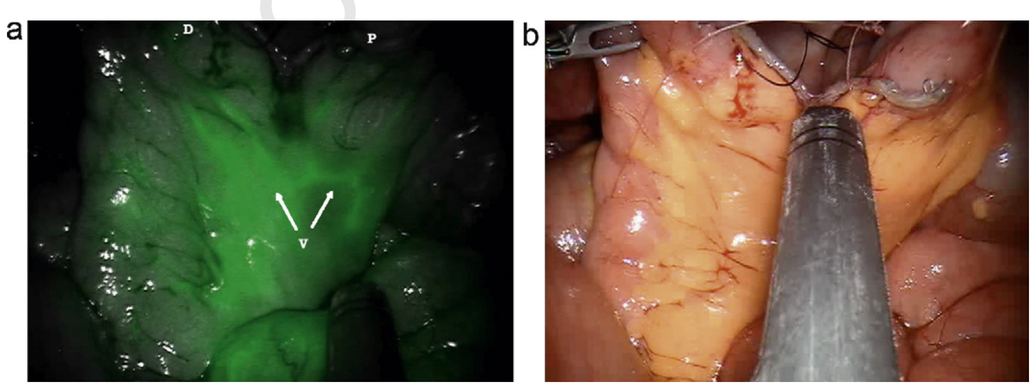

Fig. 3 – (a) Use of fluorescence imaging to confirm vascular anatomy. Distal (D) and proximal (P) ileal segments were shown with feeding vascular arcades (V) prior to (b) mesenteric stapling.

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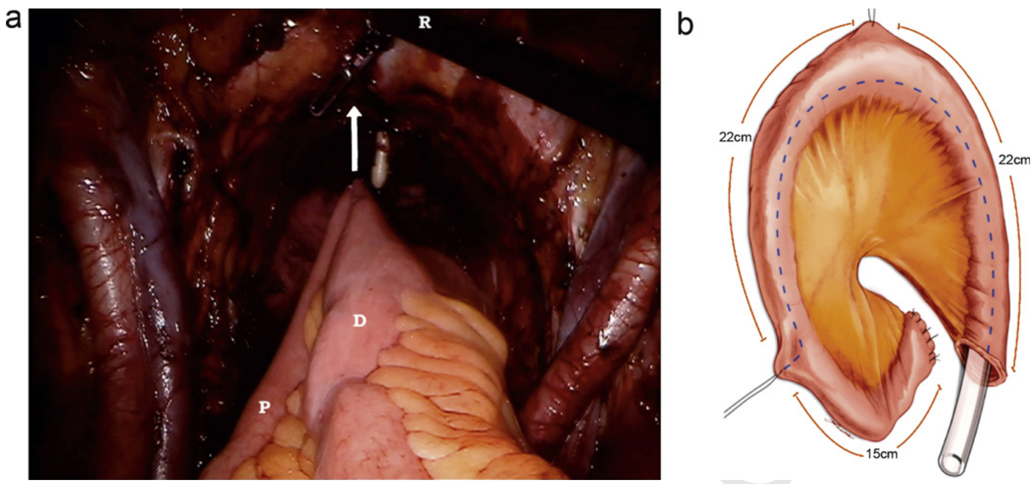

Fig. 4 – (a) Small bowel segment retracted toward the pelvis with additional robotic arm. (b) Schematic of bowel dimensions and orientation. D = distal 22-cm segment; P = proximal 22-ccm segment plus 15-cm afferent limb (not shown).

2.5. Bilateral ureteroileal anastomoses

Each ureter is spatulated and separately anastomosed to the afferent limb using the Bricker technique with continuous 4-0 Vicryl sutures [16]. After suturing the posterior wall, a 7F, single-J, ileoureteral stent is inserted. The stents are passed into the abdomen through a 2-mm MiniPort trocar (Covidien, New Haven, CT, USA) positioned just above the pubis (Fig. 6). The ureteral stents are internalized and secured to the urethral catheter with nonabsorbable sutures to facilitate stent removal approximately 3 wk postoperatively.

2.6. Completion of neobladder

Anterior closure of the pouch is completed in a running fashion using barbed sutures. The neobladder is irrigated to ensure a watertight closure; any leaks are secured with interrupted 2-0 Vicryl sutures. A closed suction drain is placed in the pelvis through a lateral port site. Specimens are extracted through extension of the midline camera port in men and transvaginally in women.

2.7. Postoperative care

All patients are managed on a clinical care pathway postoperatively. The nasogastric tube is typically removed on postoperative day 1. Sips of clear liquids are initiated, and diet is advanced with return of bowel function. Early ambulation is instituted in all patients. Starting on postoperative day 1, pouch irrigation is performed every 8 h. Patients are converted to oral pain medication once able to tolerate oral intake. The abdominal drain is removed when the output is <150 ml/d and fluid biochemistry excludes urine. A cystogram is obtained at 3 wk (Fig. 7). If no leak is observed, the catheter and stents are removed.

2.8. Statistical methods

Median, range, and proportions were used to report continuous and categorical data. Statistical analysis was performed using GraphPad Prism v.5.0 (GraphPad Software Inc, San Diego, CA, USA). Fisher exact/chi-square test and unpaired student *t* test were used for comparisons with $p < 0.05$ considered significant. Q2

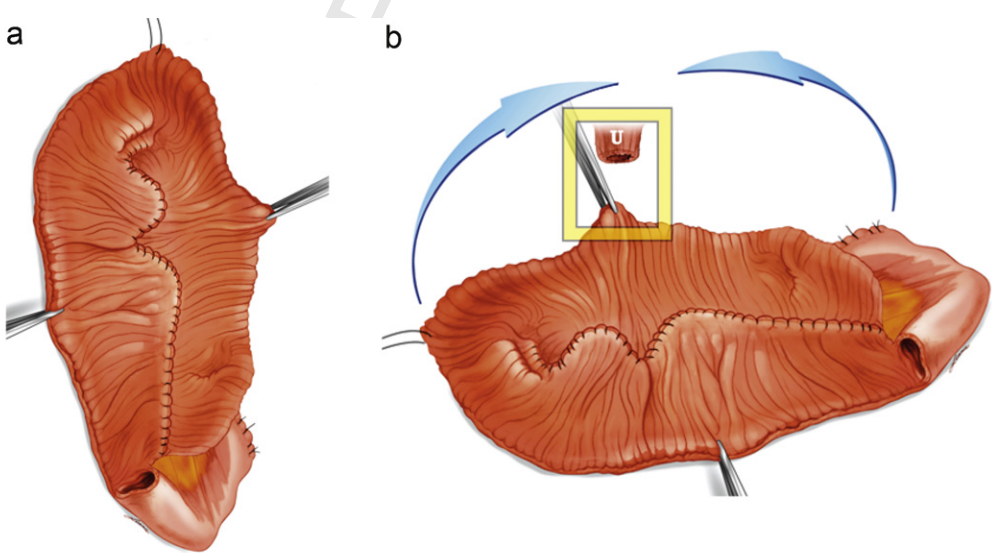

Fig. 5 – (a) Posterior wall reconstruction. (b) Rotation of pouch 90° counterclockwise with alignment for the urethroenteric anastomosis (yellow box). Blue arrows depict second folding of the bowel segment to create a globular configuration. U = urethra.

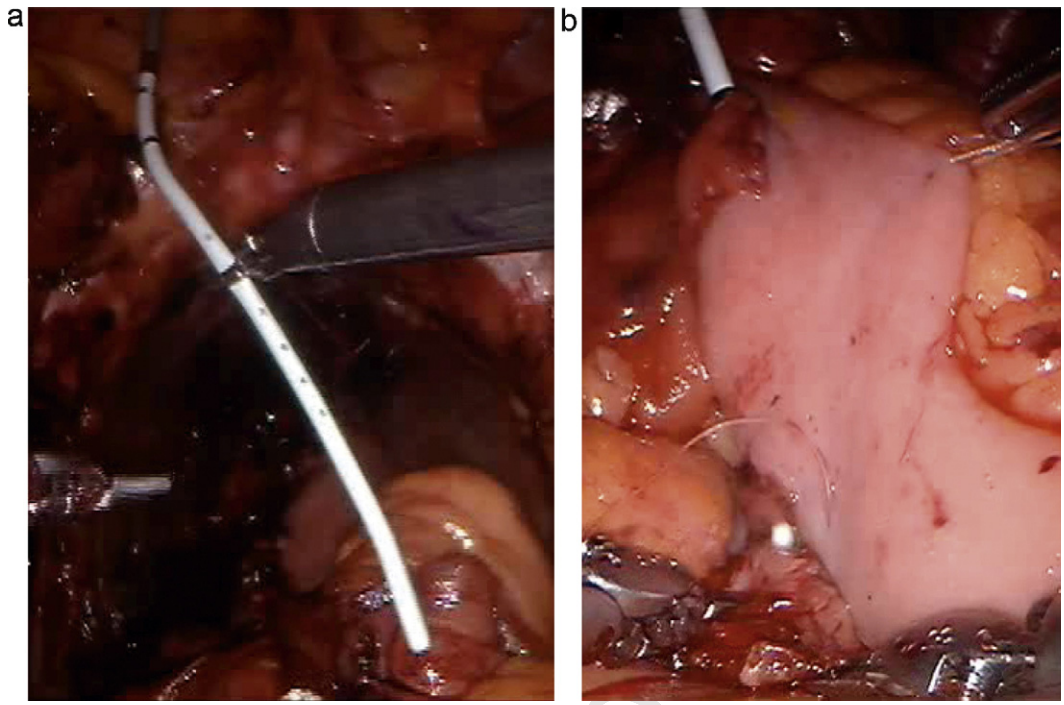

Fig. 6 – Ureteral stent placed (a) percutaneously and (b) positioned in the left ureter under direct vision.

3. Results

Robotic intracorporeal urinary diversion was successfully completed in all 15 patients (13 male, 2 female) without open conversion. Intracorporeal orthotopic ileal neobladder was constructed in eight patients, and seven patients underwent intracorporeal ileal conduit. Median patient age and BMI were 68 yr and 27 kg/m^2, respectively (Table 2). One patient had prior radiation, five patients received neoadjuvant chemotherapy, and three patients had failed intravesical bacillus Calmette-Guérin instillation.

Intraoperative and postoperative data are summarized in Table 3. Median total operative times for neobladder and ileal conduit were 7.5 h (range: 7–13) and 7.5 h

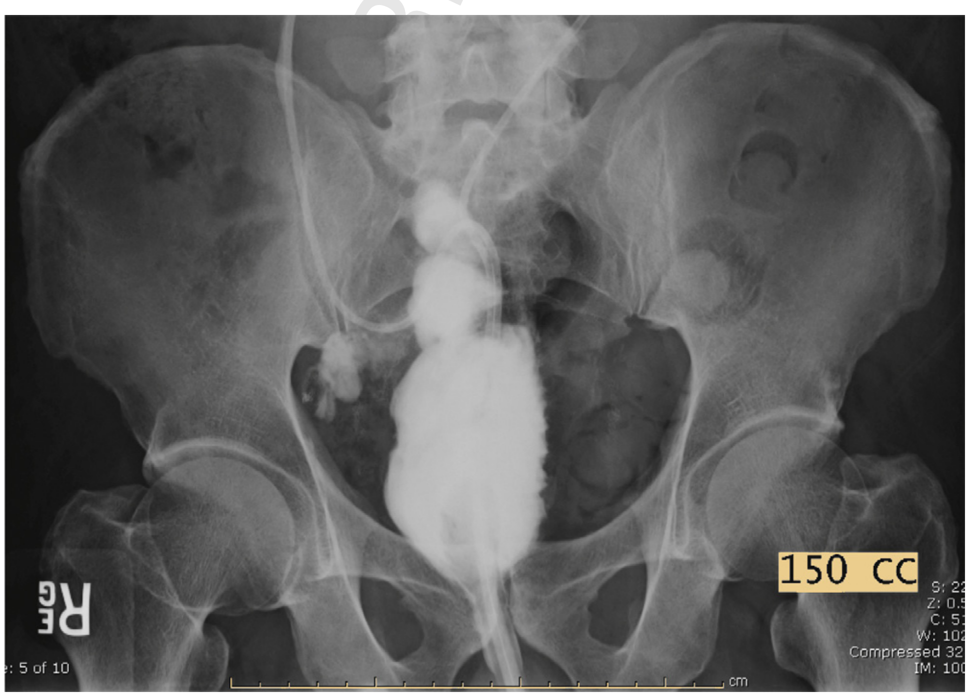

Fig. 7 – Cystogram at 3 wk postoperatively demonstrated no extravasation and a globular configuration of the pouch.

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Table 1 – Detailed comparison of published techniques of robotic intracorporeal neobladder vis-à-vis Studer's original description

Series	Studer's original description [15]	Goh et al. (current series)	Pruthi et al. [10]	Canda et al. [21]	Jonsson et al. [11]
Length of ileum used, cm	60	60	Not stated	50	50
Method of ileal detubularization	Scissors	Scissors	Stapler	Scissors	Scissors
Pouch construction	Sewn	Sewn	Titanium staples	Sewn	Sewn
Rotation of the pouch	90°	90°	None	None	None
Equal cross-folding	Yes	Yes	No	No	No
Urethroileal anastomosis	After pouch completion	After posterior wall completion	After pouch completion	Start of reconstruction	Start of reconstruction
Ureteroileal anastomosis	Bricker	Bricker	Bricker	Wallace	Wallace
Stenting	Directly, externalized	Percutaneous, internalized	Per urethra, internalized	Percutaneous, internalized	Percutaneous, externalized
Afferent limb	Yes	Yes	No	Yes	Yes
Shape	Globular	Globular	U-shaped tube	Amorphous	Amorphous
Redocking	N/A	No	Yes	Yes	Yes

N/A = not applicable.

(range: 5–10), respectively. Overall median estimated blood loss, time to regular diet, and hospital length of stay were 200 ml (range: 50–700), 6 d (range: 4–14), and 9 d (range: 5–27), respectively, and were similar between both groups ($p > 0.05$). Of note, one patient in the ileal conduit group underwent a concurrent left nephroureterectomy and another patient had prior pelvic radiation. Perioperative blood transfusion was administered in three patients undergoing a neobladder and five patients receiving an ileal conduit.

Pathology confirmed organ-confined disease in 10 patients and locally advanced disease in 5 (Table 4). All surgical margins were negative. Four patients had lymph node-positive disease.

Complications are presented in Table 5. Short-term perioperative complications (0–30 d) occurred in 11 patients (73%), including 10 patients (67%) with low-grade complications (Clavien grade 1–2) and 2 patients (13%) with high-grade complications (Clavien grade 3–5). Long-term complications (range: 31–90 d) occurred in two

Table 2 – Patient demographics

	Total	Ileal conduit	Neobladder*	p value
Patients, no.	15	7	8	
Male:female ratio	13:2	7:0	3:1	0.47
Age, yr, median (range)	68 (52–87)	69 (55–87)	63.5 (52–75)	0.26
BMI, kg/m^2, median (range)	27 (21–34)	27 (22–29)	27 (21–34)	0.70
Previous intravesical BCG therapy, no. (%)	3 (20)	2 (29)	1 (13)	0.57
Neoadjuvant chemotherapy, no. (%)	5 (33)	3 (43)	2 (25)	0.61
Previous pelvic radiation history, no. (%)	1 (7)	1 (14)	0	0.47
Precystectomy pathology, no. (%)				
T1	3 (20)	2 (29)	1 (13)	0.57
T2	9 (60)	3 (43)	6 (75)	0.31
T3	1 (7)	1 (14)	0	0.47
Other	2 (13)	1 (14)	1 (13)	1.00
Charlson comorbidity index, no. (%)				
0	7 (47)	2 (29)	5 (63)	0.31
1	5 (33)	2 (29)	3 (38)	1.00
2	1 (7)	1 (14)	0	0.47
3	2 (13)	2 (29)	0	0.20
Preoperative ASA score, no. (%)				
II	4 (27)	1 (14)	3 (38)	0.57
III	11 (73)	6 (86)	5 (63)	0.57
Previous abdominal surgery, no. (%)				
Appendectomy	3 (20)	2 (29)	1 (13)	0.57
Umbilical hernia repair	1 (7)	1 (14)	0	0.47
Nephrolithotomy	1 (7)	0	1 (13)	1.00
Radical prostatectomy	1 (7)	1 (14)	0	0.47
Smoking history				
≥10 pack-years	10 (66)	4 (57)	6 (75)	0.61
≤10 pack-years	5 (33)	3 (43)	2 (25)	0.61

BMI = body mass index; BCG = bacillus Calmette-Guérin; ASA = American Society of Anesthesiologists.
* In the orthotopic neobladder cohort, data on only the eight patients with a minimum of 90-d follow-up data are presented.

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Table 3 – Operative and postoperative parameters*

	Total	Ileal conduit	Neobladder	*p* value
Diversion type, no.(%)				
Studer	8	0	8	
Ileal conduit	7	7	0	
Operative time, h	7.5 (5–13)	7.5 (5–10)	7.5 (7–13)	0.35
Estimated blood loss, ml	200 (50–700)	200 (50–400)	225 (100–700)	0.52
Time to liquid diet, d	3 (2–7)	3.5 (3–7)	3 (2–7)	0.22
Time to regular diet, d	6 (4–14)	6 (5–14)	5 (4–10)	0.49
Length of hospital stay, d	9 (5–27)	9 (6–14)	8 (5–27)	0.67
Length of follow-up, d	93 (90–623)	99 (90–121)	91 (90–623)	0.36

* Data are given as median (range) unless otherwise indicated.

patients (one Clavien grade 2, and one Clavien grade 3b). High-grade complications occurred in two patients who received a neobladder.

Of eight patients with a neobladder and 3 mo follow-up, six have complete daytime continence, one patient wears one to two pads per day and requires occasional clean intermittent catheterization, and one patient (female) requested conversion to a continent cutaneous pouch for persistent incontinence.

4. Discussion

Although experience with robotic RC has grown with encouraging intermediate outcomes [17–19], most surgeons still perform extracorporeal urinary diversion, especially for neobladder reconstruction [18]. Our initial laparoscopic efforts with intracorporeal neobladder reconstruction were characterized by prolonged operative times and a steep learning curve [9]. Relatively higher rates of urine leak and bowel complications appeared related to technical challenges of laparoscopic intracorporeal reconstruction. Consequently, extracorporeal diversion became the mainstay during laparoscopic and robotic RC.

Several factors have contributed to recent attempts to resurrect an intracorporeal technique during robotic RC. First, techniques of robotic RC and extended lymphadenectomy have been standardized due to increasing experience with robotic pelvic surgery. As data accumulate with respect to the oncologic adequacy of the extirpative portion, focus can now be directed toward standardizing the reconstructive component. Second, the robotic platform significantly simplifies the suturing inherent to intracorporeal reconstruction. Wristed instruments, superior ergonomics, and stereoscopic high-definition visualization contribute toward improved efficiency. Third, performing the entire procedure intracorporeally may potentially lead to decreased bowel manipulation/exposure, reduced insensible fluid losses, shorter time to oral intake, and decreased incisional morbidity.

Table 4 – Pathology*

	Total	Ileal conduit	Neobladder	*p* value
Pathologic stage (pT)				
Organ-confined disease	10 (67)	4 (57)	6 (75)	0.61
pT0	4 (27)	2 (29)	2 (25)	1.00
pTis	2 (13)	1 (14)	1 (13)	1.00
PT1	0	0	0	
pT2a	1 (7)	1 (14)	0	0.47
pT2b	3 (20)	0	3 (38)	0.20
Local extravesical disease	5 (22)	3 (43)	2 (25)	0.61
pT3a	2 (13)	1 (14)	1 (13)	1.00
pT3b	1 (7)	0	1 (13)	1.00
pT4a	2 (13)	2 (29)	0	0.20
Lymph node staging and yield				
pN0	11 (73)	5 (71)	6 (75)	1.00
pN1	0	0	0	
pN2	2 (13)	1 (14)	1 (13)	1.00
pN3	2 (13)	1 (14)	1 (13)	1.00
Median LN yield, no. (range)	55 (22–95)	57.5 (22–95)	55 (44–74)	0.89
LN involvement stratified by pT stage				
≤pT1	0	0	0	
pT2	1 (7)	0	1 (13)	1.00
pT3–4	3 (20)	2 (29)	1 (13)	0.57
Positive surgical margin	0	0	0	
Incidental prostate adenocarcinoma	6 (40)	3 (43)	3 (38)	1.00
Gleason score 3 + 3	4 (27)	1 (14)	3 (38)	0.57
Gleason score 4 + 3	1 (7)	1 (14)	0	0.47
Gleason score 4 + 4	1 (7)	1 (14)	0	0.47

* All data given as no. (%) unless otherwise indicated.

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Table 5 – Complications

Type of complication	Total (N = 15)		Ileal conduit (n = 7)		Neobladder (n = 8)		p value*
	0–30 d	31–90 d	0–30 d	31–90 d	0–30 d	31–90 d	
Intraoperative	0	0	0	0	0	0	
I. Wound	0	0	0	0	0	0	
II. Pulmonary, no. (%)	1 (7)	1 (7)	0	1 (14)	1 (13)	0	30 d: 1.00
Pneumonia**	0	1	0	1 (CG 2)	0	0	90 d: 0.47
Upper respiratory infection	1	0	0	0	1 (CG 2)	0	
III. Neurologic, no. (%)	1 (7)	0	0	0	1 (13)	0	30 d: 1.00
Delirium	1	0	0	0	1 (CG 1)	0	
IV. Gastrourinary, no. (%)	2 (13)	2 (13)	1 (14)	0	1 (13)	2 (25)	30 d: 1.00
Azotemia	1	0	0	0	1 (CG 1)	0	90 d: 0.47
Urinary leak	1	0	1 (CG 1)	0	0	0	
Urinary fistula	0	1	0	0	0	1 (CG 3b)	
Ureteral stricture	0	1	0	0	0	1 (CG 3b)	
V. Infectious disease, no. (%)	5 (33)	0	1 (14)	0	4 (50)	0	30 d: 0.28
UTI	1	0	0	0	1 (CG 1)	0	
Bacteremia	2	0	1 (CG 1)	0	1 (CG 1)	0	
Sepsis	1	0	0	0	1 (CG 4b)	0	
Emphysematous pyelitis	1	0	0	0	1 (CG 3a)	0	
VI. Gastrointestinal, no. (%)	4 (27)	0	2 (29)	0	2 (25)	0	30 d: 1.00
Ileus	3	0	2 (CG 1 + CG 2)	0	1 (CG 2)	0	
Clostridium difficile colitis	1	0	0	0	1 (CG 2)	0	
VII. Cardiac, no. (%)	2 (13)	0	1 (14)	0	1 (13)	0	30 d: 1.00
Atrial fibrillation	1	0	0	0	1 (CG 2)	0	
Congestive heart failure	1	0	1 (CG 2)	0	0	0	
VIII. Bleeding, no. (%)	2 (13)	0	2 (29)	0	0	0	30 d: 0.20
Significant transfusion (>2 units)	2	0	2 (CG 2 + CG 2)	0	0	0	
IX. Thromboembolic, no. (%)	1 (7)	0	1 (14)	0	0	0	30 d: 0.47
DVT	1	0	1 (CG 2)	0	0	0	
X. Miscellaneous, no. (%)	5 (33)	1 (7)	1 (14)	0	4 (50)	1 (13)	30 d: 0.28
Dehydration	4	1	1 (CG 2)	0	3 (CG 2)	1 (CG 2)	90 d: 1.00
Anxiety disorder	1	0	0	0	1 (CG 2)	0	
Modified Clavien system complication grade							
0	4	4	1	1	3	3	
1	6	0	3	0	3	0	
2	8	2	5	1	7	1	
3a	12	0	0	0	1	0	
3b	0	2	0	0	0	2	
4b	1	0	0	0	1	0	
Minor complications (grade 1 and 2)	18	2	8	1	10	1	30 d: 1.00 90 d: 1.00
Major complications (grade 3–5)	2	2	0	0	2	2	30 d: 0.47 90 d: 1.00
Readmissions for minor complications	5	2	2	1	3	1	30 d: 1.00 90 d: 1.00
Readmissions for major complications	0	2	0	0	0	2	90 d: 1.00
Complication rate							
Overall	11 (73)	2	5	1	6	1	1.00
Minor	10 (67)	1	5	1	5	0	1.00
Major	2 (13)	1	0	0	2	1	0.47

UTI = urinary tract infection; DVT = deep vein thrombosis; CG = Clavien grade.
* Fisher exact test and unpaired t test.
** Data on specific conditions are given as no. (Clavien grade).

The first description of robotic intracorporeal neobladder was by Beecken et al. in 2003 [20]. They performed an intracorporeal Hautmann pouch with an operative time of 8.5 h. Worldwide experience with intracorporeal orthotopic neobladder is very limited and only five reports of robotic intracorporeal neobladder have been reported in the literature, with a collective experience of 64 patients, excluding the current series (Table 6).

Two recent experiences with intracorporeal neobladder were reported from Europe. In a series of 36 robotic intracorporeal neobladders, Jonsson et al. reported a median operative time of 8 h and hospital length of stay of 9 d. Early and late major complications occurred in 19% (7 of 36) and 17% (6 of 36) of patients, respectively; these rates were similar to those reported in large open series [2]. In a follow-up report by the same group, decreased operative time, length of stay, and rate of late complications over time were demonstrated [21]. In a separate report of 23 intracorporeal neobladders and 2 ileal conduits, Canda and colleagues showed a slightly longer mean operative time of 9.9 h and hospital stay of 10.5 d [22]. In their cohort, overall early and late major complications were 15% and

Table 6 – Intracorporeal urinary diversion review

Series	Ileal neobladder, no. (type)	Ileal conduit, no.	EBL, ml (range)	Operative time, h (range)	Lymph node yield, no. (range)	LOS, d (range)	Mean follow-up, mo (range)	Daytime continence*, proportion
Canda et al. [21]	23	2	429.5 (100–1200) overall	9.9 (7.1–12.4) overall	24.8 (8–46)	10.5 (7–36) overall	6.4 (2–12)	11/17
Jonsson et al. [11]	36	9	625 (200–2200) neobladder	8 (5.5–12.7) neobladder	19 (10–52)	9 (4–78) neobladder	25 (3–90)	30/31
Pruthi et al. [10]	3 (U-shape)	9	221 (50–400) overall	5.3 (4.3–7.3) overall	–	4.5 overall	–	–
Sala et al. [29]	1	–	100	12	–	5	–	1/1
Beecken et al. [19]	1 (Hautmann)	–	200	8.5	–	–	–	–
Goh et al. (current series)	8 (Studer)	7	225 (100–700) neobladder	7.5 (7–13) neobladder	55 (22–95)	8 (5–27) neobladder	3.1 (3–21)	6/8
Total	72	27	–	–	–	–	–	–

EBL = estimated blood loss; LOS = length of stay.
* 0–1 pads.

11%, respectively. In both series, the technique for intracorporeal neobladder construction was similar, with the urethroileal anastomosis performed first, followed by bowel isolation, detubularization, and reconstruction. Fixation of the urethroileal anastomosis at the start, however, may present a challenge for creation of equal segments for the posterior plate and symmetric subsequent cross-folding (Table 1). Asymmetry in the pouch could compromise optimal spherical pouch formation and potentially affect functional outcomes. Early continence rates reported by the two groups varied from 65% to 97%. Thus, long-term functional outcomes are needed to assess the modified pouch configuration.

Our perioperative outcomes are comparable to other published reports with intracorporeal diversion. The operative time in this initial robotic series was longer than open urinary diversion, as expected, and is decreasing with increasing experience. Operative time is likely to influence both perioperative morbidity and cost of treatment [19,23]. Our techniques of RC and extended lymphadenectomy components are standardized and consistently time efficient. Our current effort has focused on standardizing the technique and improving efficiency of intracorporeal diversion without deviating from established principles of orthotopic pouch configuration.

In our experience, several technical caveats have helped improve performance of intracorporeal robotic diversion. Cephalad placement of the camera and working ports create the necessary robotic workspace for efficient bowel manipulation. Placement of the assistant on the left side enables optimal application of the laparoscopic stapler through a lateral port. The fourth robotic arm, placed on the right, helps maintain bowel retraction toward the pelvis to enable efficient neobladder configuration. The use of barbed sutures also helps reduce the need to maintain continuous traction on the suture line and helped create a watertight reservoir. Using a percutaneous technique, we optimize the angle for passage of the ureteral stents, which are subsequently internalized by attachment to the urethral catheter. Last, we typically have a two-surgeon approach, wherein one surgeon performs the extirpation, and the other completes the intracorporeal reconstruction.

Orthotopic ileal neobladder reconstruction following RC is a challenging and complex operation regardless of the approach. The open experience with orthotopic diversion has suggested that several principles are critical to ensure successful functional and physiologic outcomes. Studer et al. proposed that an ideal neobladder should have large capacity for storage, and low pressure and high compliance for continence, and should permit voluntary emptying without residual urine [15]. A spheroidal configuration was proposed with the advantages of minimizing surface area, maximizing storage volume, and decreasing pressure with detubularization and cross-folding. Urodynamic studies have confirmed excellent results when these principles are used for pouch creation [24,25]. A low-pressure, high-capacity system would also be protective of upper tract deterioration, and optimal surface-to-volume ratio can help to minimize metabolic derangements [26]. Long-term functional data are excellent, with reports of daytime continence >90% in several large series [27,28]. Our technique of robotic intracorporeal neobladder aims to replicate these tenets by duplicating intestinal segment lengths and pouch configuration as performed open surgically at our institution.

Some authors have described laparoscopic stapling to construct a modified pouch more expediently. Data from the Kock pouch experience have documented the detrimental effects of staples in the urinary tract [29]. We adhere to a sewn reconstruction for all intracorporeal diversions. In addition, we preserve Studer's original description of sequential orthogonal folding to take advantage of the principle of Laplace, thereby generating a low-pressure, high-capacity globular reservoir. To create the spheroidal shape, it is important to have equally folded bowel segments. Performing the urethroileal anastomosis after constructing the posterior wall enables equal folding of the ileal segments and fixes the pouch in place to allow facile anterior closure without the need for repositioning or redocking. We also believe a running urethroileal anastomosis can be advantageous by decreasing urine leak and formation of anastomotic stricture.

Technological advancements may further improve the ease and efficiency of robotic intracorporeal diversion.

The development of tissue-sealant device attachments for the robotic platform can decrease reliance on the bedside assistant and potentially decrease use of disposable items, thereby decreasing cost. Absorbable endoscopic stapling technology may alleviate the need for intracorporeal suturing and reduce operative times. Imaging technology, like fluorescence enhancement, can provide additional anatomic information and may help assess vascular integrity of bowel segments. We typically rely on predictable anatomic landmarks, including the ileocecal junction and avascular plane of Treves, for bowel selection in our open and robotic urinary diversions. However, we have found that fluorescence imaging can readily highlight bowel vascularity and may serve as an excellent adjunct for identification of important arterial supply.

Our report is limited by short follow-up and a small sample size. Although our indications for intracorporeal neobladder mirror those for the open procedure, selection bias may be introduced by external referral patterns. Carefully constructed prospective trials combined with greater experience and reproducible techniques will need to corroborate the safety and benefits of robot-assisted intracorporeal neobladder reconstruction. Long-term follow-up and standardized evaluation of functional outcomes, including urodynamic studies, are necessary to confirm the efficacy of our approach.

5. Conclusions

We demonstrate our step-wise technique for robot-assisted intracorporeal ileal neobladder, while respecting established open surgical principles. Increasing experience using a standard approach has helped improve efficiency. Further investigation is needed to evaluate long-term outcomes of intracorporeal urinary diversion.

Author contributions: Alvin C. Goh had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Goh, Desai, Gill.
Acquisition of data: Goh, Lee, Abreu, Fairey, Leslie, Berger, Gill.
Analysis and interpretation of data: Goh, Desai.
Drafting of the manuscript: Goh.
Critical revision of the manuscript for important intellectual content: Goh, Desai, Gill, Aron, Daneshmand, Sotelo.
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Appendix A. Supplementary data

The Surgery in Motion video accompanying this article can be found in the online version at http://dx.doi.org/10. 1016/j.eururo.2012.07.052 and via www.europeanurology.com.

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