A comparative study of robot-assisted laparoscopic intracorporeal versus open urinary diversion

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INTRODUCTION

In a number of centers with robotic technology, robot-assisted radical cystectomy (RARC) has become a feasible treatment option for patients with muscle-invasive and high-risk superficial urothelial bladder cancer. In the past decade, RARC has superseded the use of pure laparoscopic radical cystectomy and is becoming a more available option at major tertiary care centers. Recent...
studies have reported no significant differences in terms of the oncological outcome following either RARC or open radical cystectomy (ORC). Conventionally, an extracorporeal urinary diversion (ECUD) was preferred following completion of RARC because of the complexity of the procedure and longer operating time. The evolution of robotic surgery, with its three-dimensional vision, 10-fold magnification, and dexterity provided by the endowristed instruments, has made intracorporeal suturing much easier. This technology adds a new aspect to reconstructive surgery, enabling the surgeon to perform both continent and incontinent urinary diversions intracorporeally. Intracorporeal urinary diversion (ICUD) is gaining popularity as a viable alternative to ECUD with the potential benefits of a smaller incision, reduced pain, decreased bowel exposure, and reduced risk of fluid imbalances and, subsequently, decreased risk of postoperative ileus. Studies comparing only perioperative outcomes of urinary diversion are scarce. We aimed to compare the perioperative outcomes and complications of ICUD and ECUD with or without concurrent cystectomy either for malignant or benign disease performed in our institution.

SUBJECTS AND METHODS

Patients
A retrospective chart review was done to evaluate the perioperative outcomes of patients who underwent ICUD and ECUD. The analysis was conducted in the Department of Urology at the University of Arkansas for Medical Sciences (Little Rock, AR). The electronic medical record system was queried between May 2016 and June 2018 to identify all patients who underwent urinary diversion, ICUD or ECUD. Data were collected from patient charts. Patients were identified for the study if they (1) underwent urinary diversion with concurrent radical cystectomy for biopsy-proven, muscle-invasive transitional cell carcinoma (MITCC), squamous cell carcinoma (SCC), or high-grade, nonmuscle-invasive urothelial carcinoma refractory to intravesical Bacillus Calmette–Guerin treatment; (2) those who underwent urinary diversion after cystectomy for benign diseases such as neurogenic bladder and radiation/hemorrhagic cystitis; or (3) those who underwent urinary diversion only.

Study design
Perioperative data, including 90-day complications, were collected after obtaining the approval of the institutional review board. The data included patient demographics (age, gender, body mass index [BMI], and ethnicity), American Society of Anesthesiologists (ASA) score for preoperative physical status, diagnosis, history of neoadjuvant chemotherapy, previous irradiation, prior abdominal surgery, and the concurrent surgery. The operative (OP) techniques were performed by three different fellowship-trained surgeons. The choice between ICUD and ECUD was based on surgeon’s preference and expertise as well as other patient factors (e.g., patients who had a history of extensive abdominal surgery were offered ECUD).

Outcomes of interest
The primary study outcome was to evaluate the perioperative outcomes in patients undergoing ICUD and ECUD. The outcomes that were considered included OP time, estimated blood loss (EBL), intraoperative events or complications, early postoperative pain requiring narcotics, length of stay (LOS), time to flatus/bowel movement, 90-day complications, reoperation rate, and readmission rate. All complications within 90 days of surgery were identified, defined, graded according to the Clavien–Dindo classification of surgical complications, and grouped into 11 categories by organ system.

Statistical analysis
Data were collected, revised, coded, and entered to the Statistical Package for Social Sciences Statistics 23.0 (IBM, Armonk, NY, USA). The quantitative data were presented as mean, standard deviations (SDs), and ranges when their distribution was found to be parametric and as median with interquartile range when their distribution was found to be nonparametric. The comparison between groups regarding qualitative data was done using Chi-square test. The comparison between two independent groups with quantitative data and parametric distribution was done using independent t-test, and comparison with nonparametric distribution was done using Mann–Whitney test.

RESULTS

Patient demographics
A total of 35 patients who underwent urinary diversion (ICUD or ECUD) were identified. Of these patients, 21 (60%) had ECUD (19 ileal conduits [90.5%] and 2 ileal neobladders [9.5%]) and 14 (40%) had ICUD (13 ileal conduits [92.9%] and 1 neobladder [7.1%]). In terms of patient characteristics [Table 1], no significant differences were observed between the groups except for the ASA score. More patients with an ASA score ≥3 were in the ECUD group (85.7%) than in the ICUD group (42.9%, P = 0.007). Among both groups, there were no significant differences in age.
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Table 1: Patient demographics and preoperative characteristics

| Characteristics          | Total (n=35)     | ICUD (n=14)     | ECUD (n=21)     | P     |
|-------------------------|------------------|-----------------|-----------------|-------|
| Age (years)             | 62.14±11.27      | 66.43±6.16      | 59.29±13.04     | 0.065 |
| Mean±SD                 | 28-75            | 55-75           | 28-75           |       |
| Gender, n (%)           |                  |                 |                 |       |
| Female                  | 15 (42.9)        | 6 (42.9)        | 9 (42.9)        | 1.000 |
| Male                    | 20 (57.1)        | 8 (57.1)        | 12 (57.1)       |       |
| BMI                     | 28.21±7.05       | 27.43±6.20      | 28.73±7.67      | 0.600 |
| Mean±SD                 | 16.15-49.24      | 21-43.18        | 16.15-49.24     |       |
| Ethnicity, n (%)        |                  |                 |                 |       |
| Caucasian               | 30 (85.7)        | 14 (100.0)      | 16 (76.2)       | 0.049 |
| African-American        | 4 (11.4)         | 0               | 4 (19.0)        | 0.083 |
| Hispanic                | 1 (2.9)          | 0               | 1 (4.8)         | 0.407 |
| ASA score, n (%)        |                  |                 |                 |       |
| <3                      | 11 (34.4)        | 8 (57.1)        | 3 (14.3)        | 0.007 |
| >3                      | 24 (68.6)        | 6 (42.9)        | 18 (85.7)       |       |
| Prior abdominal surgery, n (%) | 16 (45.7)        | 8 (57.1)        | 8 (38.1)        | 0.268 |
| Preoperative chemotherapy, n (%) | 17 (48.6)        | 9 (64.3)        | 8 (38.1)        | 0.129 |
| Preoperative irradiation, n (%) | 3 (8.6)          | 0               | 3 (14.3)        | 0.139 |
| Diagnosis, n (%)        |                  |                 |                 |       |
| Neurogenic bladder      | 5 (14.3)         | 2 (14.3)        | 3 (14.3)        | 1.000 |
| Radiation cystitis      | 3 (8.6)          | 0               | 3 (14.3)        | 0.139 |
| MITCC                   | 24 (68.6)        | 12 (85.7)       | 12 (57.1)       | 0.074 |
| MISCC                   | 1 (2.9)          | 0               | 1 (4.8)         | 0.407 |
| Urethral adenocarcinoma | 1 (2.9)          | 0               | 1 (4.8)         | 0.407 |
| Surgical procedure, n (%) |                  |                 |                 |       |
| Ileal conduit           | 32 (91.4)        | 13 (92.9)       | 19 (90.5)       | 0.805 |
| Ileal neobladder        | 3 (8.6)          | 1 (7.1)         | 2 (9.5)         | 0.805 |

ICUD: Intracorporeal urinary diversion, ECUD: Extracorporeal urinary diversion, SD: Standard deviation, BMI: Body mass index, ASA: American Society of Anesthesiologists, MITCC: Muscle-invasive transitional cell carcinoma, MISCC: Muscle-invasive squamous cell carcinoma

(mean ± SD: 62.14 ± 11.27 years), gender (57% males), mean BMI (28.21 ± 7.05 kg/m²), or ethnicity (85.7% Caucasians). Both groups were similar to the total proportion of patients who had prior abdominal surgery (45.7%), preoperative chemotherapy (48.6%), or preoperative irradiation (8.6%). Preoperative chemotherapy was recorded only in patients who were diagnosed with MITCC (85.7% in the IUCD group and 57.1% in the ECUD group, P = 0.13).

The most prevalent preoperative diagnosis in both groups was MITCC of the bladder. The remainder of patients in the ICUD group was diagnosed with neurogenic bladder (14.3%). Other preoperative diagnoses of patients in the ECUD group included neurogenic bladder (14.3%), radiation cystitis (14.3%), muscle-invasive SCC (4.8%), and urethral adenocarcinoma (4.8%). Only three (14.3%) patients, all in the ECUD group, received preoperative irradiation. Two were female patients who received irradiation because of gynecological malignancies. The remaining patient had a history of external beam radiation therapy for localized prostate cancer with a subsequent salvage open radical prostatectomy. In the 2 years following this event, the patient experienced recurrent gross hematuria with clots, suprapubic pain, and recurrent urinary tract infection. The patient subsequently underwent radical cystectomy with ECUD.

Perioperative outcomes

The ICUD group demonstrated longer mean total OP time (minutes ± SD: 457.14 ± 103.91) when compared to the ECUD (388.29 ± 110.17, P = 0.07). The EBL volume was assessed and estimated by the surgeon. The median EBL was statistically significantly less in the ICUD group (250 ml) versus the ECUD group (450 ml, P = 0.05) [Table 2]. The most common concurrent procedure done in the ECUD group was ORC (n = 9, 42.8%). Other surgeries done were RARC (n = 5, 23.8%), open supratrigonal cystectomy (n = 5, 23.8%), and robotic simple cystectomy (n = 1, 4.8%). Only one patient (4.8%) in the ECUD group underwent only urinary diversion.

Perioperative surgical complications were recorded in two patients (14.3%) in the ICUD group and three patients (14.3%) in the ECUD group. In ICUD, complications reported were: (1) rectal injury, which was repaired primarily by the general surgery team; and (2) conversion to open surgery due to the presence of extensive adhesions between the posterior bladder wall and rectum which led to failure to progress. Complications in the ECUD group were: (1) internal iliac artery injury, which was managed by controlling the bleeding and ligation of the artery; (2) splenic capsular injury, which was managed by applying two sheets of a hemostatic agent (Surgicel®); and (3) hemodynamic...
instability (a side effect of inhalational anesthetic agent) with mild dehydration, which was managed by vasopressor medications and intravenous fluids.

Postoperatively, patients who had early pain requiring narcotics were recorded more in the ECUD group (28.6%) than in the ICUD group (14.3%, \( P = 0.32 \)). The mean LOS (days ± SD) was not significantly different; however, the ICUD group (6.29 ± 2.61) reported shorter period versus the ECUD group (8.10 ± 4.29, \( P = 0.16 \)). Recorded time to flatus/bowel movement for patients in ICUD (3.29 ± 1.20) was similar to that of ECUD (4.19 ± 1.86, \( P = 0.11 \)) [Table 2]. Patients with persistent (beyond postoperative day [POD] 5) high-drain creatinine were identified and reported only in the ECUD group (8.10 ± 4.29, \( P = 0.16 \)). Only one patient (4.8%) in the ECUD group who underwent ileal conduit reported dusky and retracted stoma with clear urine output on POD 3, which was managed conservatively, and a follow-up revealed stable functioning stoma.

### Readmission and reoperation characteristics

Compared to the ICUD (9.5%) group, the ECUD group demonstrated no statistically significant difference in the 30-day reoperation rate (14.3%, \( P = 0.19 \)) or the 30-day readmission rate (21.4% for ICUD versus 23.8% for ECUD, \( P = 0.86 \)) [Table 2]. Causes of readmission for patients in the ICUD groups were port site cellulitis, pelvic fluid collection on POD 7, and acute kidney injury on POD 25. Causes of readmission for patients in the ECUD group were abdominal abscess (2.8 cm in maximum diameter) on POD 13, pelvic hematoma (3.2 cm) with right-sided pyelonephritis on POD 15, fascial dehiscence with acute kidney injury, urosepsis, and pyocystis.

Causes of reoperation for patients in the ICUD group were exploration after suspicion of intra-abdominal bleeding and laparotomy with resection of ischemic small bowel segment. Causes for patients in the ECUD group were abdominal closure of wound dehiscence by retention sutures and stapled vaginal vesicostomy after development of pyocystis.

### Ninety-day complications

The 90-day complication rates were categorized using the Clavien–Dindo classification of surgical complications and were not significantly different between the two groups, although higher rates were observed in the ECUD group [Table 2]. The reported complications were mainly low grade (Clavien–Dindo classification Grades I–II, 35.7% in ICUD and 38.1% in ECUD), whereas high-grade complications (Grades III–V) were encountered to a lesser degree (28.6% in ICUD and 33.3% in ECUD).

Postoperative infections (i.e., port-site cellulitis, purulent wound infection, and pelvic abscess) along with gastrointestinal complications (i.e., ileus, leakage, and ischemia) constituted the majority of the complications, occurring 31.4% in the ICUD group and 34.3% in the ECUD group [Table 3]. There was one case of mortality in each group (\( P = 0.8 \)), both because of cardiological events (myocardial infarction in one patient and atrial fibrillation with rapid ventricular response in the other).

### DISCUSSION

The current study compares a single-institution cohort of patients undergoing intracorporeal and extracorporeal diversions mostly after cystectomy for various benign and malignant conditions. Compared to patients in the ECUD group, patients who underwent ICUD demonstrated long OP time and less EBL. Postoperatively, patients in the ICUD group recorded shorter hospital stays, reduced need for narcotics for early postoperative pain, and shorter time to flatus/bowel movement compared to patients in the ECUD group. Patients in the ECUD group demonstrated high rates of 90-day complications when compared to patients in the ICUD. However, low-grade complications were more frequently encountered than the high-grade complications in both groups.

Robotic radical cystectomy and urinary diversion are deemed technically challenging procedures that require...
extensive OP experience. Earlier reports on ICUD have been promising, and it will become more popular as the surgeons’ experiences and skills increase.\textsuperscript{[11]} Although intracorporeal diversion of urine has a steep learning curve and requires advanced robotic suturing skills, as experience increases, the OP times for ICUD are likely to decrease.\textsuperscript{[13]}

Ng \textit{et al.} recorded a mean OP time of 5.95 h for ORC followed by ECUD compared to 6.25 h for RARC followed by ECUD.\textsuperscript{[14]} In a report by Ahmed \textit{et al.} on patients who underwent ICUD and ECUD following RARC in the International Robotic Cystectomy Consortium (IRCC), the authors reported no difference in the OP times between the two groups (414 min).\textsuperscript{[15]} The former studies’ findings come in concordance with our findings; there was no significant difference in the OP time between the two groups, however being longer in the ICUD group. We acknowledge that we encountered difficulties in recording the specific time of the urinary diversion step compared to the total OP time which included induction and recovery of anesthesia as well as the concurrent surgeries done in the same setting with urinary diversion.

In the report by Ahmed \textit{et al.},\textsuperscript{[15]} the EBL for ECUD and ICUD was similar (375 ml and 385 ml, respectively), $P = 0.75$. Similarly, in the study of Kang \textit{et al.} of a cohort of 25 patients who underwent robotic versus open ileal conduit, the EBL was not statistically significantly different between the two groups (400.3 ml vs. 370 ml, $P = 0.39$).\textsuperscript{[16]} In our report, we recorded significant reduced EBL ($P = 0.05$) in the ICUD versus the ECUD. This might be related to the better visualization and subsequent control of bleeding vessels in the contemporary da Vinci system (Si and Xi) with evolution of more recent hemostatic agents and instruments such as robotic automatic staplers which help surgeons in better handling of intraoperative bleeding events.

Potential short LOS has been a strong impetus for adoption of RARC versus ORC. In the report of Hanna \textit{et al.} of 9561 patients utilizing the National Cancer Database in the USA, the authors identified and compared patients who underwent ORC versus RARC. They reported that the RARC group was associated with a shorter median LOS (7 days vs. 8 days, $P < 0.001$).\textsuperscript{[17]} Similarly, in a recent study on 4760 patients who were identified by a National Medicare claims database in the USA between 2008 and 2015, Modi \textit{et al.} recorded that RARC group was associated with shorter LOS when compared to ORC (10.1 days vs. 11.9 days, $P < 0.001$).\textsuperscript{[17]} Our results in terms of LOS are in line with the other national reports, with shorter LOS in the ICUD group when compared to the ECUD although the difference was not statistically significant.

Our study recorded a rate of 14.3% for 30-day reoperation in the ICUD group versus 9.5% in the ECUD group, $P = 0.19$. In a single-institution study of 92 patients, the authors retrospectively reviewed the records of all patients who underwent surgical interventions after RARC-specific complications between 2005 and 2015. The reoperation rates were 5%, 2%, and 16% at 30, 31–90, and >90 days, respectively. Interventions for ureteroileal complications were the most common ($n = 48$) followed by interventions for bowel obstruction, fistulas, and abdominal wall-related complications ($n = 11$).\textsuperscript{[18]}

The postoperative complications of RARC have been reported in several reports. In the IRCC report on over 900 patients who underwent RARC, the authors recorded the 30- and 90-day complications. Results showed nonsignificant difference in the complication rates between the ICUD and ECUD groups, but the trend appeared to favor the ICUD group. Overall, there were 239 (33%) low-grade complications (Clavien–Dindo Grade I–II) for both the groups (196 [31%] and 43 [23%] for EUCD and ICUD groups, respectively). High-grade (Clavien–Dindo Grade III–V) complications were reported in 115 (18%) patients in the ECUD group and 34 (18%) in the ICUD group.\textsuperscript{[19]} In addition, the studied patients had a 32% less likelihood of a complication to occur if the urinary diversion was performed intracorporeally (odds ratio: 0.68, 95% confidence interval: 0.50–0.94).\textsuperscript{[19]} In the same context, Novara \textit{et al.} performed a systematic literature review of 105 papers and cumulative analysis of perioperative

### Table 3: Complications according to the organ system involved

| Complication category | Total, $n$ (%) | ICUD, $n$ (%) | ECUD, $n$ (%) | $P$ |
|-----------------------|---------------|---------------|---------------|-----|
| General*              | 8 (22.9)      | 3 (21.4)      | 5 (23.8)      | 0.869 |
| Infection             | 12 (34.3)     | 3 (21.4)      | 9 (42.9)      | 0.191 |
| Gastrointestinal      | 11 (31.4)     | 3 (21.4)      | 8 (38.1)      | 0.298 |
| Genitourinary         | 2 (5.7)       | 0             | 2 (9.5)       | 0.234 |
| Cardiac               | 3 (8.6)       | 1 (7.1)       | 2 (9.5)       | 0.805 |
| Pulmonary             | 1 (2.9)       | 0             | 1 (4.8)       | 0.407 |
| Renal                 | 4 (11.4)      | 2 (14.3)      | 2 (9.5)       | 0.664 |
| Vascular              | 2 (5.7)       | 1 (7.1)       | 1 (4.8)       | 0.766 |
| Head/neck             | 2 (5.7)       | 1 (7.1)       | 1 (4.8)       | 0.766 |
| Wound                 | 1 (2.9)       | 0             | 1 (4.8)       | 0.407 |
| Metabolic             | 1 (2.9)       | 1 (7.1)       | 0             | 0.214 |

*Defined as “severe anemia (Hb <10 mg/dl), convulsions, delirium of nonspecified cause.” Defined as “acute abdomen whether resulting from a mechanical or nonmechanical cause. It also includes other complications like ischemia and leakages from anastomotic sites.”

ICUD: Intracorporeal urinary diversion, ECUD: Extracorporeal urinary diversion, Hb: Hemoglobin
outcomes and complications of RARC in comparison with ORC and laparoscopic radical cystectomy. In the series reporting on RARC with extracorporeal conduit diversion, results showed the overall 30- and 90-day complication rates to be 44% and 59%, respectively.[19] Low-grade complications were the most prevalent. In addition, in the series reporting on RARC with intracorporeal conduit diversion, the overall complication rates at 30, 30–90, and 90 days were 67%, 22%, and 59%, respectively. High-grade complications were present in 24%, 20%, and 15% at 30, 30–90, and 90 days, respectively.[19]

Our study demonstrates comparable results with the former national and meta-analysis studies with regard to 90-day complications. Overall, the encountered complications were minor grade (35.7%–38.1%) rather than the high-grade (28.6%–33.3%) complications and were not statistically significantly different between both the groups (P = 0.656). Postoperative infection (i.e., abdominal/pelvic abscess) was the most prevalent encountered complication (34.3%) in our study. This was equivalent to a prospective trial in the Memorial Sloan Kettering Cancer Center on 118 bladder cancer patients who were randomized to ORC or RARC, both with ECUD. The types of complications observed were similar in each arm, with infectious complications being the most commonly identified. The only statistically significant difference identified was related to wound complications, more commonly observed in ORC group.[20]

The main limitations of this study were the study being of retrospective nonrandomized nature and constituting small series of patients. This is due to the low number of patients with MIBC and high-risk non-MIBC in whom radical cystectomy is indicated. In addition, this study represents an analysis of a single institution in the USA and may not be generalizable to the US population at large despite being ostensibly concordant to several national-level studies in most of the outcomes. More prospective long-term, large studies comparing ICUD versus ECUD after RARC are warranted to better evaluate the possible advantages and outcomes of ICUD.

CONCLUSIONS

Our results demonstrate that the ICUD is technically feasible and safe with acceptable morbidity. ICUD results in decreased blood loss, shorter hospital stays, and lower rates of 90-day complications when compared with ECUD.

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Conflicts of interest
There are no conflicts of interest.

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