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Outcomes of Intracorporeal Urinary Diversion after Robot-Assisted Radical Cystectomy: Results from the International Robotic Cystectomy Consortium

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1 **Outcomes of Intracorporeal Urinary Diversion after Robot-Assisted Radical Cystectomy:**
2 **Results from the International Robotic Cystectomy Consortium**

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50 **Abstract**

51 **Introduction and Objective:** This study aims to provide an update and compare perioperative
52 outcomes and complications of Intracorporeal urinary diversion (ICUD) and extracorporeal
53 urinary diversion (ECUD) following RARC from a multi-institutional, prospectively maintained
54 database, the International Robotic Cystectomy Consortium (IRCC).

55 **Methods:** A retrospective review of 2125 patients from 26 institutions was performed. ICUD
56 was compared with ECUD Multivariate (stepwise variable selection) logistic regression models
57 were fit to evaluate preoperative, operative, and postoperative predictors of receiving ICUD,
58 operative time, high grade complications and 90-days readmissions after RARC.

59 **Results:** 51% (n=1094) patients underwent ICUD in our cohort. ICUD patients demonstrated
60 shorter operative times (357 vs 400 minutes, $p<0.001$), less blood loss (300 vs 350 ml, $p<0.001$),
61 and fewer blood transfusions (4% vs 19%, $p<0.001$). ICUD patients experienced more high
62 grade complications (13 vs 10%, $p=0.02$). Utilization of ICUD increased from 9% of all urinary
63 diversions in 2005 to 97% in 2015. Complications after ICUD decreased significantly over time
64 ($p<0.001$). On multivariable analysis, higher annual cystectomy volume (OR 1.02, 95% CI
65 (1.01-1.03), $p<0.002$) and year of RARC 2013-2016 (OR 68, 95% CI 44-105, $p<0.001$) and ASA
66 score <3 (OR 1.75, 95% CI 1.38-2.22, $p<0.001$) were associated with receiving ICUD. ICUD
67 was associated with shorter operative time (27 minutes, $p=0.001$).

68 **Conclusion:** Utilization of ICUD has increased over the past decade. Higher annual institutional
69 volume of RARCs was associated with performing ICUD. ICUD was associated with shorter
70 operative times. Although ICUD was associated with higher grade complications compared to
71 ECUD, they decreased over time.

72

73 **Introduction**

74 Utilization of robot-assisted radical cystectomy (RARCs) has witnessed a paramount
75 increase in the past decade (1). While RARC has been associated with improved perioperative
76 outcomes such as blood loss, hospital stay, and improved convalescence, much of the criticism
77 has been attributed lack of tactile feedback and the longer operative time, especially with
78 intracorporeal approach to urinary diversion and also with construction of a continent reservoir.
79 Consequently, most surgeons performed a hybrid approach with extracorporeal construction of
80 urinary diversion.

81 Expertise and continuous refinement of the technique has cut down both operative times and
82 costs (2). Consequently, operative time has been identified as a quality measure for surgical
83 performance for RARC (3, 4). In a recent study, RARC and intracorporeal ileal conduit has been
84 shown to be technically feasible and without jeopardizing outcomes (3, 5). On the other hand,
85 intracorporeal neobladders are more technically challenging, time-consuming with steep learning
86 curve and thereby they have been slower to adopt, and only confined to high volume academic
87 institutions. Nevertheless, several techniques for intracorporeal neobladders have been recently
88 described with promising functional and oncologic outcomes (6-9).

89 Intracorporeal urinary diversion (ICUD) provides benefits in terms of a complete
90 minimally invasive technique, including smaller incisions, reduced pain, decreased bowel-related
91 complications, and reduced risk of third space losses and fluid imbalances (10, 11). This study
92 aims to provide an update and compare perioperative outcomes and complications of ICUD and
93 extracorporeal urinary diversion (ECUD) following RARC from a multi-institutional,
94 prospectively maintained database, the International Robotic Cystectomy Consortium (IRCC).

95

96 Methods

97 A retrospective review of 2432 patients from 29 institutions included in the IRCC
98 database (I-97906) was performed. Patients who had missing data about the diversion approach
99 or technique were excluded from the study. The final cohort comprised 2125 patients from 26
100 institutions who were treated with RARC since 2005. Data were reviewed for age, gender, body
101 mass index [BMI], American Society of Anesthesiologists [ASA] score, preoperative
102 characteristics (neoadjuvant chemotherapy, prior abdominal surgery, and clinical staging),
103 institutional volume, year of RARC, operative variables (type and technique of diversion,
104 operative time, estimated blood loss, and blood transfusion), perioperative outcomes
105 (complications, readmissions, hospital and intensive care unit stay), and pathologic outcomes
106 (staging, lymph node yield and soft tissue surgical margins). Technique of RARC and urinary
107 diversion, and follow up differed among institutions. ICUD was compared with ECUD in terms
108 of complications, survival, and patterns of recurrence.

109 Descriptive statistics were used to summarize the data. Univariable associations were
110 statistically assessed using Wilcoxon Rank-Sum, Pearson Chi-square or Fisher's Exact test.
111 Univariate and multivariate (stepwise variable selection) logistic regression models were fit to
112 evaluate preoperative, operative, and postoperative predictors of receiving ICUD, operative time,
113 high grade complications and any readmission after RARC. The Kaplan Meier method was used
114 to depict recurrence-free (RFS), disease specific (DSS) and overall survival (OS). Cox
115 proportional hazards regression models were fit to evaluate predictors of survival outcomes. All
116 tests were two-sided, with statistical significance defined as $p \leq 0.05$. All statistical analyses were
117 performed using SAS software (version 9.4, SAS Institute Inc., Cary, NC).

118

119 **Results**

120 Fifty-one percent (n=1094) patients underwent ICUD. Utilization of ICUD increased
121 from 9% of all urinary diversions in 2005 to 97% in 2016, with a rate of increase of 11%/year
122 (Figure 1). This increase has been primarily demonstrated for intracorporeal ileal conduits
123 (increased from 2% in 2005 to 81% in 2016) and to a lesser extent for intracorporeal neobladders
124 (from 7% in 2005 to 17% in 2016) (Figure 2). US institutions started to utilize ICUD more
125 frequently in 2009 (22% of all diversions), and increased to 91% in 2015. In contrast, European
126 institutions adopted ICUD earlier in their robotic experience (40% of all diversion in 2008 and
127 reached 100% in 2016) (Figure 3).

128 Compared to patients who received ECUD, ICUD patients included fewer patients with
129 ASA score ≥ 3 (44% vs 53%, $p < 0.001$), and received neoadjuvant chemotherapy more frequently
130 (25% vs 17%, $p < 0.001$). ICUD patients demonstrated shorter operative times (357 vs 400 min,
131 $p < 0.001$), less blood loss (300 vs 350 ml, $p < 0.001$) and received blood transfusion less
132 frequently (5% vs 13%, $p < 0.001$). There was no significant difference in terms of receiving
133 neobladders (21% vs 23%, $p = 0.32$). ICUD patients experienced complications more often (57%
134 vs 43%, $p < 0.001$) especially within the first month after RARC (31 vs 19%, $p < 0.001$). However,
135 the incidence of high grade complications after ICUD decreased significantly over time (from
136 25% in 2005 to 6% in 2015, $p < 0.001$), and remained stable for ECUD (13% in 2005 and 14% in
137 2015, $p = 0.76$) (Figure 4). ECUD showed more overall readmissions (34% vs 26%, $p = 0.003$)
138 (Table 1).

139 Both groups were comparable in terms of $\geq pT3$ disease (38% vs 39%, $p = 0.59$), positive
140 nodal disease (18% vs 19%, $p = 0.51$), lymph node yield (11 vs 12, $p = 0.90$) and positive soft
141 tissue surgical margins (7% each, $p = 0.71$). ECUD patients experienced more distant recurrences

142 (18% vs 14%, $p=0.005$), but less extrapelvic lymph node metastasis (1% vs 3%, $p=0.01$) and
143 peritoneal carcinomatosis (0.3% vs 1.3%, $p=0.01$) (Table 2).

144 On multivariable analysis, higher annual RARC volume (Odds ratio [OR] 1.02, 95%
145 Confidence Interval [CI] (1.01-1.03), $p=0.002$), year of RARC 2013-2016 (OR 68, 95% CI 44-
146 105, $p<0.001$) and ASA score <3 (OR 1.75, 95% CI 1.38-2.22, $p<0.001$) were associated with
147 receiving ICUD (Table 3). On the other hand, shorter operative time was associated with older
148 age (1 minute shorter for each 1 year increase in age, $p<0.001$), annual cystectomy volume (1
149 minute shorter per 1 case increase in annual RARC volume, $p=0.01$), date of RARC (2013-2016
150 vs 2005-2008) (23 minutes shorter, $p=0.01$) and ICUD (27 minutes shorter, $p<0.001$). On the
151 other hand, BMI (estimate of 4 minutes longer for each 1 Kg/m², $p<0.001$), ASA ≥ 3 (22 minutes
152 longer, $p<0.001$) and receiving a neobladder (64 minutes longer, $p<0.001$) were associated with
153 longer operative time (Table 4).

154 History of prior abdominal surgery (OR 1.52 95% CI 1.06-2.15, $p=0.02$) was the only
155 significant factor associated with high grade complications. Higher BMI (OR 1.05, 95% CI 1.02-
156 1.07, $p=0.0002$), high grade complications (OR 2.22, 95 %CI 1.56-3.15, $p<0.0001$) were
157 significantly associated with any readmission after RARC (Table 5).

158 Both groups exhibited similar RFS and DSS (Log rank $p= 0.97$ and 0.80 , respectively).
159 However, ICUD experienced worse OS (85%, 62% and 49% vs 85%, 69% and 58% at 1, 3 and 5
160 years, respectively) (log rank $p=0.05$) (Figure 5). For RFS, patients with $\geq pT3$ (HR 3.51, 95%CI
161 2.76-4.45, $p<0.001$) and $pN+$ (HR 2.72, 95%CI 1.81-2.86, $p<0.001$) had worse RFS, while
162 RARCs performed 2009-2013 (HR 0.72, 95% CI 0.57-0.92, $p=0.03$) demonstrated better RFS
163 when compared to RARCs performed 2005-2009. For DSS, patients with higher lymph node

164 yield demonstrated marginal benefit (HR 0.97, 95% CI 0.96-0.99, $p=0.01$), while patients with
165 positive soft tissue surgical margins (HR 1.66, 95% CI 1.07, 2.56, $p=0.02$), $\geq pT3$ (HR 5.63, 95%
166 CI 3.89-8.13, $p<0.001$) and $pN+$ disease (HR 2.18, 95% CI 1.58-3.01, $p<0.001$) demonstrated
167 worse DSS. For OS, high grade complications (HR 1.55, 95% CI 1.14-2.11, $p=0.006$), $ASA\geq 3$
168 (HR 1.36, 95% CI 1.10-1.70, $p=0.005$), positive margins (HR 1.46, 95% CI 1.06-2.00, $p=0.02$),
169 $\geq pT3$ (HR 3.52, 95% CI 2.73-4.54, $p<0.001$) and $pN+$ (HR 1.78, 95% CI 1.39-2.29, $p<0.001$)
170 were associated with worse OS. Patients with neobladders had better OS (HR 0.49, 95% CI 0.30-
171 0.70, $p<0.001$) (Table 6).

172 Discussion

173 Much of the criticism for ICUD has been attributed to the steep learning curve and longer
174 operative time, especially if an orthotopic bladder substitute is planned. Our data shows that
175 utilization of ICUD has increased over the past decade, reaching 97% in 2015 among IRCC
176 members. This is contrast with prior reports that showed limited use of ICUD in the US (3% of
177 RARCs) (12). Predictors of receiving ICUD were annual RARC volume, as well as cystectomy
178 era (2013-2016) and ASA score < 3 . It is notable that ICUD was adopted earlier in Europe when
179 compared to the US (4). Prior reports showed that a stepwise approach to RARC and PLND
180 allowed safe incorporation of ICUD (3). The technique of RARC, extended pelvic lymph node
181 dissection (PLND) has been optimized, and as with experience in human-robot interaction,
182 ICUD became more popular with development of multiple techniques for more complex
183 intracorporeal neobladders (7, 9, 10, 13-15). A team approach combined with mentoring,
184 especially during the early learning curve, will further reduce operative time and complications
185 (16). Although there was no significant difference in the diversion type between ICUD and
186 ECUD, the increase in utilization of ICUD has been primarily demonstrated for ileal conduits

187 (2% in 2005 to 81% in 2016) when compared to intracorporeal neobladders (from 7% in 2005 to
188 17% in 2016). Intracorporeal neobladder is more technically demanding and this may explain
189 this pattern. Whether the approach to urinary diversion affects the decision for urinary diversion
190 choice is still unclear(17).

191 With increased experience and comfort with the robotic platform, operative times for
192 RARC have decreased over time (18). ICUD was associated with shorter operative time in this
193 study in contrast to prior reports (11). This could be either due to increased comfort and
194 experience with ICUD and flattening of the learning curve, or due to the additional time of
195 undocking of the robot and preparing the patient for ECUD, which adds to the total operative
196 time. Higher BMI, and neobladders may add to the complexity of RARC, with more time spent
197 in port placement, careful dissection as well as LND (19, 20). Filson et al examined the different
198 factors that may contribute to operative times and divided them into modifiable (such as extent
199 of LND, diversion type and technique) and non-modifiable factors (such as age, gender in
200 addition to institutional and surgeon factors) (21). They observed longer operative times with
201 neobladders and with more extensive LNDs. Older age and the number of comorbidities were
202 significantly associated with shorter operative times, which they explained by that surgeons
203 anticipate higher anesthetic complications and tend to be faster in older and sicker patients.
204 Female gender was also associated with longer operative times, which may be attributed to prior
205 gynecologic procedures rather than a true gender-related difference (20). Higher annual RARC
206 volume and more recent cystectomy era were associated with shorter operative time. More
207 experience and flattening of the learning curve associated with more procedures performed
208 would lead to cutting down of operative times. Similar to this study, higher surgical volume has
209 been associated with shorter operative times for RC (21-23).

210 In an earlier report from IRCC (ICUD n=167, 18%), ICUD was associated with lower
211 gastrointestinal and 90-day complication rates (11). The current study shows that patients who
212 received ICUD had higher overall and high grade complications, especially within the first
213 month after RARC. We believe that earlier experience was subject to patient selection bias. With
214 increased utilization of ICUD and broadening of the patient selection, the actual burden of
215 RARC, rather than ICUD, was observed (4). Interestingly, the incidence of high grade
216 complications after ICUD decreased over time, while it remained stable for ECUD. Moreover,
217 on multivariable analysis prior abdominal surgery was the only significant predictor of high
218 grade complications. The presence of higher BMI and high grade complications were
219 significantly associated with readmissions. The approach to urinary diversion (ICUD vs ECUD)
220 was not a significant predictor of neither. About two-thirds of complications necessitating
221 reoperations following RARC occur beyond 3 months of RARC. Therefore, it is important to
222 report readmissions and complications beyond 3 months to avoid underestimation of the actual
223 burden of the procedure (24).

224 There was significant difference between both approaches in terms of RFS or DSS. In
225 agreement with the robotic and open cystectomy literature, survival outcomes after cystectomy
226 are mainly driven by disease-related factors, including pT stage, nodal status and positive
227 surgical margins (25-28). Patients with ECUD experienced more distant recurrences when
228 compared to ICUD. In agreement with a prior report from IRCC, the incidence of peritoneal
229 carcinomatosis and port site recurrences are low (1% and 0.3%, respectively) (26). Despite the
230 statistical difference between ICUD and ECUD in extrapelvic lymph node metastasis and
231 peritoneal carcinomatosis, the small numbers limit any conclusions that can be made. Patients
232 with ECUD experienced better OS at 3 and 5 years, likely because of the higher complication

233 rate associated with ICUD especially early in the ICUD experience. Nevertheless, diversion
234 approach was not significantly associated OS. Patients who received neobladders had better OS
235 likely because of patient selection bias rather than a true benefit of the urinary diversion type.
236 Younger patients with fewer comorbidities and more favorable disease are more likely to be
237 offered orthotopic bladder substitutes, and therefore more likely to have better survival outcomes
238 (29).

239 To our knowledge, this is largest reported series of ICUD. However, several limitations
240 exist. The inherent limitations to retrospective analysis should be acknowledged. The variability
241 among institutions in the IRCC in terms of surgical technique, institutional follow up protocols
242 and pathology reporting, and lack of detailed complications and comorbidity data apart from that
243 presented are other limitations (supplementary tables 1 and 2). IRCC includes mainly high
244 volume institutions and experienced surgeons, which may limit the generalizability of the results.

245 **Conclusion**

246 Utilization of ICUD has dramatically increased over the past decade. Higher annual
247 institutional volume of RARCs was associated with performing ICUD. ICUD was associated
248 with shorter operative times. Although ICUD was associated with higher grade complications
249 compared to ECUD, they decreased over time. More surgeons are incorporating ICUD as part of
250 their RARC with standardization and evolution of the technique.

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332

Table 1. Demographics, clinical characteristics and perioperative outcomes of patients who underwent ICUD versus ECUD.

Preoperative parameters	ECUD	ICUD	All	p-value
N of patients (%)	1031 (49)	1094 (51)	2125	0.17
Age at cystectomy, mean (SD) (yr)	68 (11)	67 (10)	67 (11)	0.03
Gender, Males n (%)	827 (81)	780 (71)	1607 (76)	< 0.001
Body Mass Index, mean (SD) (kg/m ²)	27.5 (5)	27.3 (5)	27.4 (5)	0.23
ASA score \geq 3, mean (SD)	484 (53)	337 (44)	821 (49)	< 0.001
Prior abdominal/pelvic surgery, n (%)	375 (41)	264 (45)	639 (43)	0.17
Prior irradiation, n (%)	35 (6)	24 (5)	59 (6)	0.73
Clinical T stage, \geq cT3, n (%)	149 (15)	118 (14)	267 (15)	0.36
Neo-adjuvant chemotherapy, n (%)	175 (17)	254 (25)	429 (21)	< 0.001
Perioperative outcomes				
Type of diversion, neobladder, n (%)	236 (23)	231 (21)	467 (22)	0.32
Operative time, median (IQR) (min)	400 (338-480)	357 (297-420)	371 (310-450)	< 0.001
Estimated blood loss, median (IQR) (ml)	350 (200-550)	300 (105-500)	300 (200-500)	< 0.001
Blood Transfusion, n (%)	135 (13)	50 (5)	185 (8)	< 0.001
Postoperative outcomes				
Any complication	441 (43)	623 (57)	1064 (50)	< 0.001
Clavien 3-5	99 (10)	141 (13)	240 (11)	0.02
30-d complications	195 (19)	335 (31)	530 (25)	< 0.001
30-90 d complications	40 (4)	50 (5)	90 (4.2)	0.43
Any readmission	147 (34)	213 (26)	360 (29)	0.003
0-30-d readmissions, n (%)	56 (5)	57 (5)	113 (5.3)	0.82
30-90-d readmissions, n (%)	34 (3)	46 (4)	80 (3.8)	0.27
90-d mortality, n (%)	27 (3)	27 (3)	54 (3)	0.73
Adjuvant chemotherapy, n (%)	156 (21)	116 (13)	272 (16)	< 0.001
Hospital stay, median (IQR) (days)	8 (6-12)	9 (7-14)	9 (7-13)	< 0.001
Intensive Care Unit stay, median (IQR) (days)	0 (0-1)	1 (0-1)	1 (0-1)	< 0.001
Follow up, median (months) (IQR)	17 (7-32)	11 (4-25)	13 (5-29)	< 0.001

Table 2. Pathologic outcomes and sites of disease relapse

Pathological outcomes	ECUD	ICUD	All	p-value
Pathologic T stage, \geq pT3, n (%)	372 (39)	391 (38)	763 (39)	0.59
Lymph node yield, mean	19 (12)	18 (11)	18 (11)	0.90
N positive, n (%)	198 (19)	198 (18)	396 (19)	0.51
Positive surgical margins, n (%)	74 (7)	74 (7)	148 (7)	0.71
Any recurrence, n (%)	244 (24)	204 (19)	448 (19)	0.005
Recurrence Site	ECUD	ICUD	All	p-value
Local recurrence, n (%)	101 (10)	107 (10)	208 (10)	1.00
Pelvis	43 (4)	47 (4)	90 (4)	0.91
Vagina	1 (0.1)	3 (0.3)	4 (0.3)	0.63
Rectum	8 (0.8)	7 (0.6)	15 (0.6)	0.80
Perineum	3 (0.3)	10 (0.9)	13 (0.9)	0.09
Urethra	7 (0.7)	2 (0.2)	9 (0.2)	0.10
Penile	0 (0)	2 (0.2)	2 (0.2)	0.50
Neobladder/Conduit	1 (0.1)	3 (0.3)	4 (0.3)	0.63
Kidney	1 (0.1)	3 (0.3)	4 (0.3)	0.63
Multiple Local	8 (0.8)	13 (1)	21 (1)	0.39
Unidentified site	42 (4)	29 (3)	71 (3)	0.07
Distant recurrence, n (%)	188 (18)	151 (14)	339 (14)	0.005
Nodal	14 (1)	33 (3)	47 (3)	0.01
Lung	36 (4)	38 (4)	74 (4)	1.00
Liver	16 (2)	18 (2)	34 (2)	1.00
Bone	24 (2)	34 (3)	58 (3)	0.29
Brain	1 (0.1)	6 (0.5)	7 (0.5)	0.13
Abdominal wall	3 (0.3)	4 (0.4)	7 (0.4)	1.00
Multiple distant	14 (1)	29 (3)	43 (2.7)	0.04
Unidentified site	111 (11)	58 (5.3)	169 (5.3)	<0.001
Peritoneal carcinomatosis	3 (0.3)	14 (1.3)	17 (1.3)	0.01
Port-site recurrence	0 (0)	3 (0.3)	3 (0.3)	0.25

Table 3. Stepwise multivariable logistic regression modeling predictors for receiving ICUD

Parameter	Odds Ratio	95% Confidence Interval	p-value
Annual RARC volume	1.02	(1.01, 1.03)	0.002
Cystectomy Era (2009-2012) vs (2005-2008)	7.95	(5.6, 11.4)	< 0.001
Cystectomy Era (2013-2016) vs (2005-2008)	67.8	(43.8, 105)	< 0.001
ASA < 3	1.75	(1.38, 2.22)	< 0.001

Table 4. Stepwise multivariable linear regression modeling predictors for longer operative time

Parameter	Estimate (min)	p-value
Intercept	376	<0 .001
Age at Cystectomy	-1	<0.001
Body Mass Index	4	<0.001
ASA \geq 3	22	<0.001
Average Cyst per Year	-1	<0.001
Cystectomy Era (2013-2016) [2005-2008]	-23	0.01
Neobladder	64	<0.001
ICUD	-27	<0.001

Table 5. Stepwise multivariable regression modeling predictors for high grade complications and any readmission

High grade complications	Odds Ratio	95% Confidence Interval	p-value
Previous Abdominal Surgery	1.52	(1.08, 2.15)	0.02
Any readmission	Odds Ratio	95% Confidence Interval	p-value
Body Mass Index	1.05	(1.02, 1.07)	0.0002
Clavien 3-5	2.22	(1.56, 3.15)	< 0.0001

Table 6. Multivariable Cox proportional hazards modelling predictors of OS.

RFS	Hazard Ratio	95% Confidence Interval	p-value
Cystectomy era (2009-2013)	0.72	(0.57, 0.92)	0.03
Cystectomy era (2013-2017)	0.85	(0.62, 1.18)	0.32
pN+	2.72	(1.81, 2.86)	<0.001
≥pT3	3.51	(2.76, 4.45)	< 0.001
DSS	Hazard Ratio	95% Confidence Interval	p-value
Lymph node yield	0.97	(0.96, 0.99)	0.01
Positive margins	1.66	(1.07, 2.56)	0.02
pN+	2.18	(1.58, 3.01)	<0.001
≥pT3	5.63	(3.89, 8.13)	< 0.001
OS	Hazard Ratio	95% Confidence Interval	p-value
BMI	0.97	(0.95, 0.99)	0.003
High grade complications	1.55	(1.14, 2.11)	0.006
ASA≥3	1.36	(1.10, 1.70)	0.005
Neobladder	0.49	(0.30, 0.70)	<0.001
Positive margins	1.46	(1.06, 2.00)	0.02
pN+	1.78	(1.39, 2.29)	<0.001
≥pT3	3.52	(2.73, 4.54)	< 0.001

Figure 1: Diversion approach by year. ICUD increased from 9% in 2005 to 97% in 2015. Increase of 11% per year ($p < 0.001$)

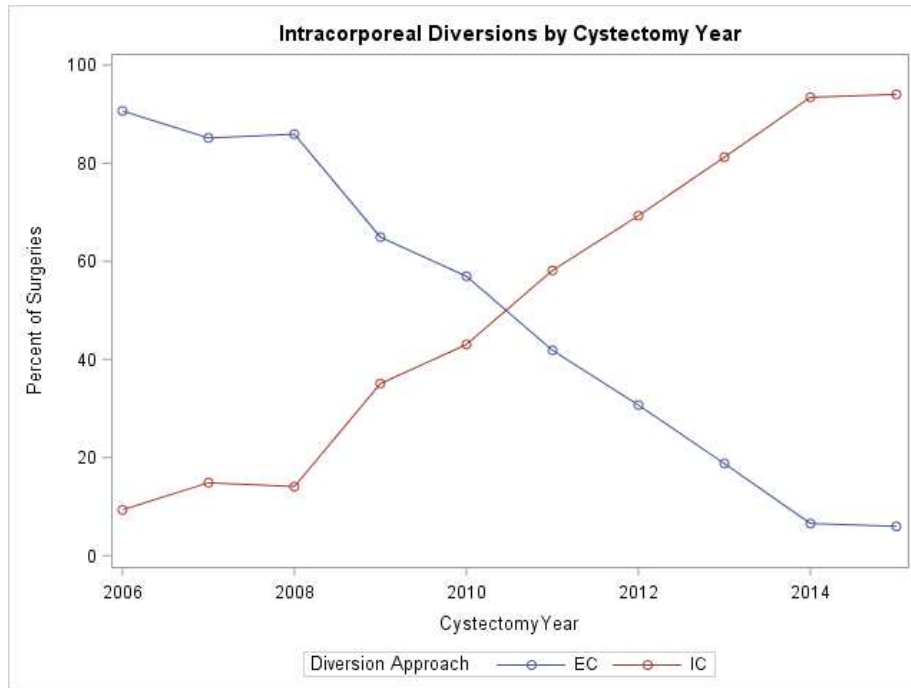


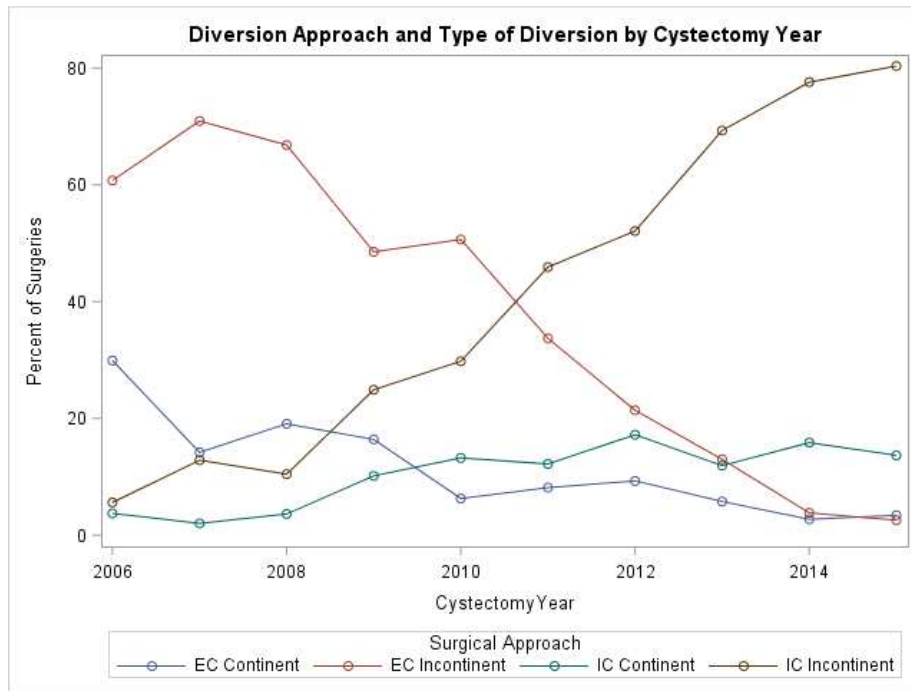
Figure 2: Diversion type and approach by year

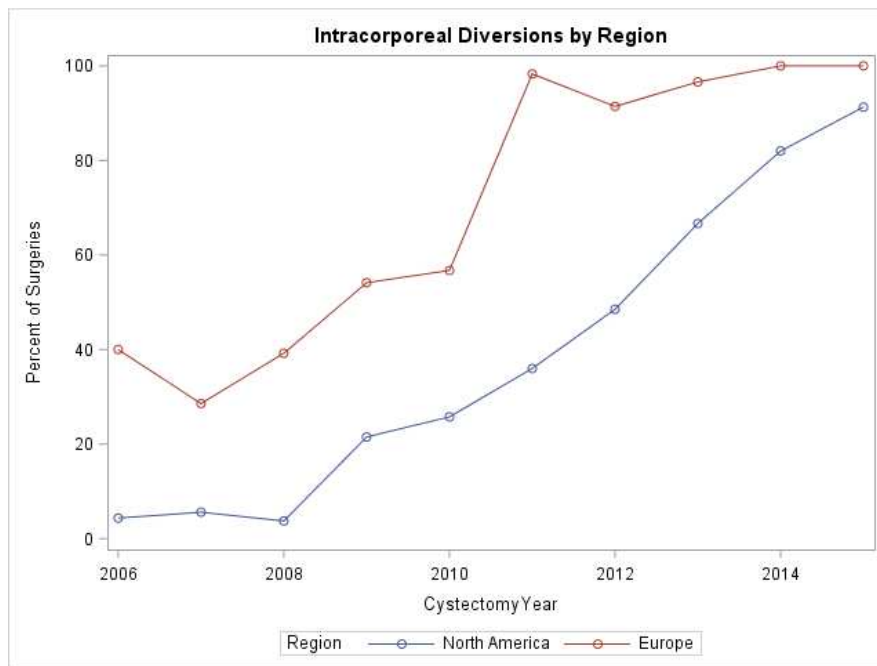
Figure 3: Diversion Approach by Region

Figure 4: High grade complications after ICUD decreased from 25% in 2005 to 6% in 2015 (decrease of 2%/year, $p < 0.001$). For ECUD, they remained stable (13% in 2006 to 14% in 2015 ($p = 0.76$)).

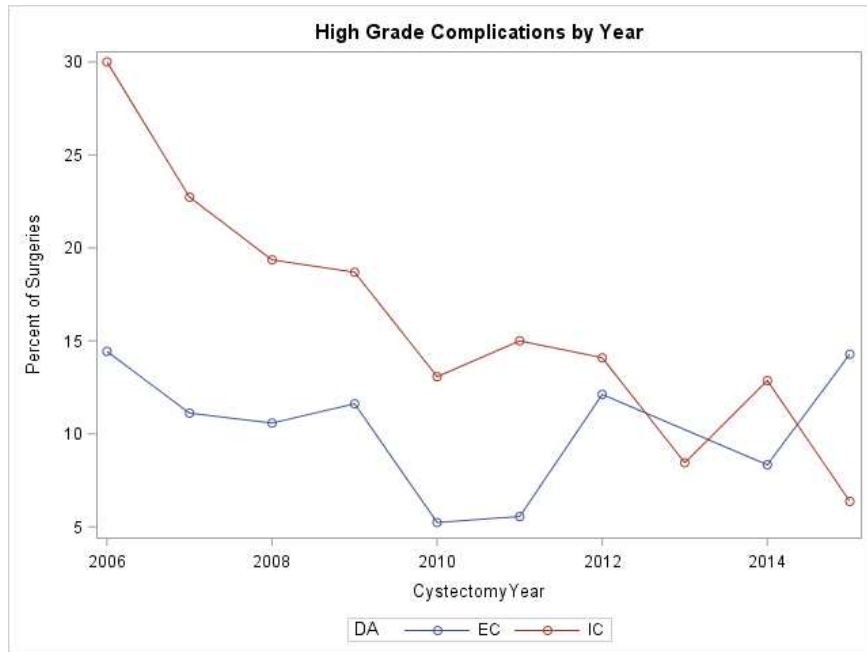
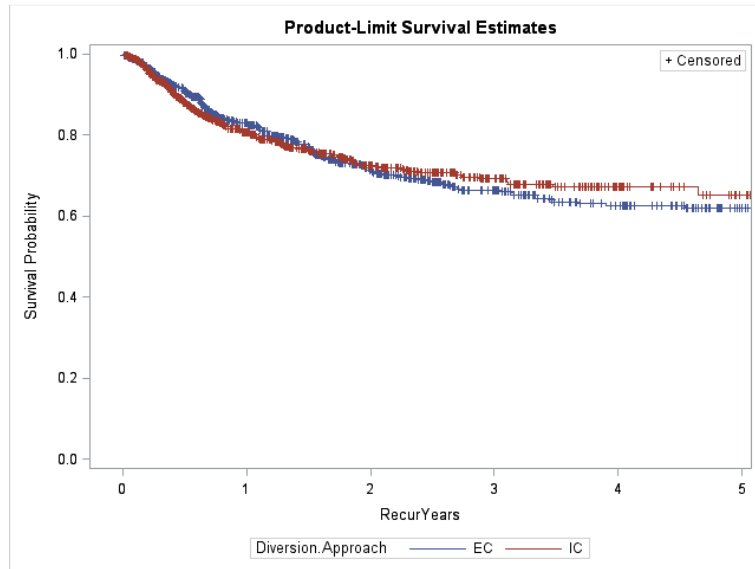


Figure 5: A. Kaplan Meier curves depicting RFS for patients who received ICUD vs ECUD after RARC (log rank $p=0.97$)



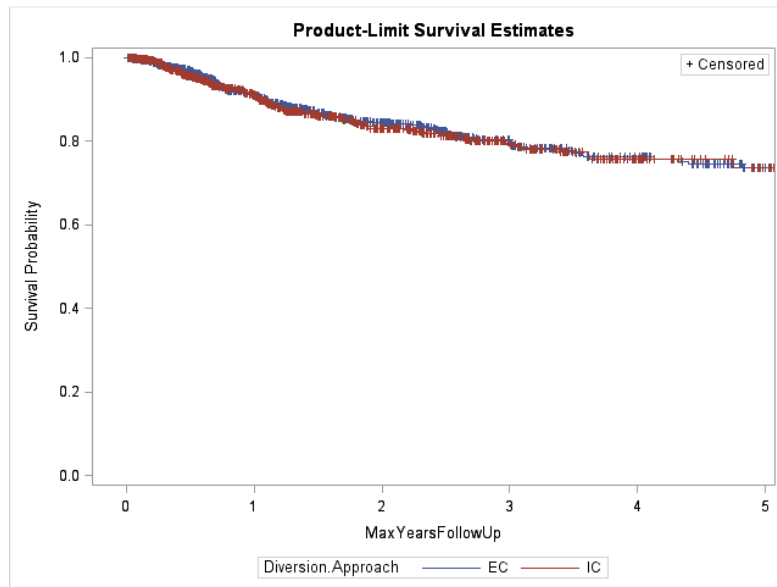
IC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	152	439	818.5	1	0
1	2	35	166	364	0.81	0.19
2	3	9	116	188	0.74	0.26
3	4	3	65	88.5	0.70	0.30
4	5	1	27	39.5	0.68	0.32
5	.	2	23	13.5	0.66	0.34

EC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	128	272	770	1	0
1	2	62	130	441	0.84	0.16
2	3	17	115	256.5	0.72	0.28
3	4	9	45	159.5	0.67	0.33
4	5	1	46	105	0.63	0.37
5	.	5	76	43	0.63	0.37

B. Kaplan Meier curves depicting DSS for patients who received ICUD vs ECUD after RARC (log rank $p=0.80$)



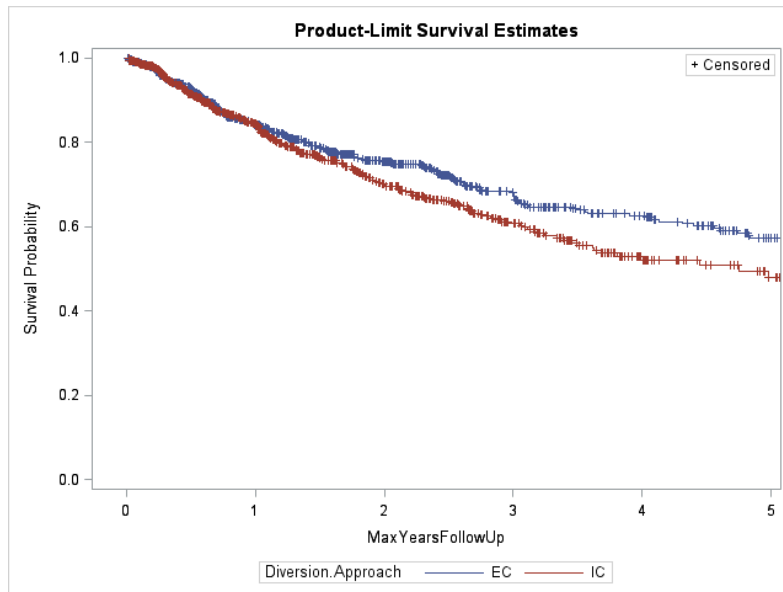
IC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	65	472	802	1	0
1	2	36	191	405.5	0.92	0.08
2	3	9	132	208	0.84	0.16
3	4	5	70	98	0.80	0.20
4	5	1	29	43.5	0.76	0.24
5	.	0	28	14	0.74	0.26

EC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	64	301	755.5	1	0
1	2	33	162	460	0.92	0.08
2	3	14	131	280.5	0.85	0.15
3	4	9	53	174.5	0.81	0.19
4	5	4	45	116.5	0.77	0.23
5	.	4	86	47	0.74	0.26

C. Kaplan Meier curves depicting OS for patients who received ICUD vs ECUD after RARC (log rank $p=0.046$)



IC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	123	414	831	1	0
1	2	70	157	422.5	0.85	0.15
2	3	28	113	217.5	0.71	0.29
3	4	15	60	103	0.62	0.38
4	5	3	27	44.5	0.53	0.47
5	.	1	27	14.5	0.49	0.51

EC:

Interval		Failed	Censored	Effective Sample Size	Survival	Failure
[Lower,	Upper)					
0	1	119	246	783	1	0
1	2	50	145	468.5	0.85	0.15
2	3	26	119	286.5	0.76	0.24
3	4	15	47	177.5	0.69	0.31
4	5	10	39	119.5	0.63	0.37
5	.	17	73	53.5	0.58	0.42

Supplementary Table 1: RARCs/institution/year

Institution	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	Total
1	0	0	0	0	3	26	13	9	9	8	11	0	79
2	0	0	2	2	8	2	0	0	0	0	0	0	14
3	0	0	0	0	0	0	0	2	11	0	0	0	13
4	2	16	1	2	11	5	11	7	37	0	0	0	92
5	16	16	8	22	16	4	0	0	0	0	0	0	82
6	0	0	1	12	2	0	0	0	0	0	0	0	15
7	0	0	0	0	0	2	0	0	0	0	0	0	2
8	0	0	1	8	9	8	0	0	0	0	0	0	26
9	6	4	9	16	41	38	0	0	0	0	0	0	114
10	3	5	16	8	13	3	8	14	4	0	0	0	74
11	1	5	2	8	19	19	15	48	84	43	0	0	244
12	0	0	0	0	0	0	2	8	6	2	0	0	18
13	0	0	0	0	0	5	0	0	0	0	0	0	5
14	0	0	0	0	0	0	1	0	0	0	0	0	1
15	0	0	0	1	0	5	7	7	2	0	0	0	22
16	12	6	15	14	4	1	0	0	0	0	0	0	52
17	0	0	0	0	0	2	16	19	25	36	23	0	121
18	3	30	33	47	42	44	36	45	45	45	46	36	452
19	0	0	0	0	0	0	5	15	33	41	34	0	128
20	0	0	8	5	36	36	21	15	0	3	3	0	127
21	0	0	3	3	25	13	0	0	0	0	0	0	44
22	0	4	4	3	7	3	0	0	0	0	0	0	21
23	0	21	31	32	24	29	18	25	21	5	0	0	206
24	0	0	0	18	29	42	19	1	0	0	0	0	109
25	0	0	8	11	9	10	0	0	0	0	0	0	38
26	0	0	6	8	7	5	0	0	0	0	0	0	26
Total	43	107	148	220	305	302	172	215	277	183	117	36	2125

Supplementary Table 2: Comorbidities of patients who underwent ECUD vs ICUD

Variable Name	EC	IC	All (n)	All (%)	P Value
Number of Patients	1031 (48.52)	1094 (51.48)	2125		0.172
Myocardial Infarction	42 (10.99)	43 (6.96)	85	8.5	0.026
Arrhythmia	40 (8.64)	45 (7.27)	85	7.86	0.407
Congestive Heart Failure	10 (2.62)	44 (7.12)	54	5.4	0.002
Peripheral Vascular Disease	20 (5.28)	39 (6.39)	59	5.97	0.471
Carotid Disease	9 (2.37)	24 (4.04)	33	3.39	0.162
Cardiovascular Disease	129 (22.87)	131 (21.41)	260	22.11	0.545
Renal Insufficiency	27 (7.07)	61 (9.89)	88	8.81	0.127
Dementia	2 (0.53)	7 (1.15)	9	0.91	0.495
Asthma	13 (3.44)	26 (4.29)	39	3.96	0.506
COPD	74 (13.17)	81 (13.28)	155	13.23	0.955
Arthritis	49 (13)	60 (9.88)	109	11.08	0.13
Peptic Ulcer Disease	24 (6.37)	31 (5.13)	55	5.61	0.414
Diabetes Mellitus	149 (19.33)	135 (21.74)	284	20.4	0.267
Stroke	20 (5.31)	20 (3.29)	40	4.06	0.119
Liver Disease	45 (9.34)	13 (2.13)	58	5.32	< 0.001
DVT/PE	12 (3.18)	34 (5.59)	46	4.67	0.082
Hypertension	400 (59.88)	331 (53.56)	731	56.84	0.022

Key of Definitions:

- Robot-assisted radical cystectomy (RARCs)
- Intracorporeal urinary diversion (ICUD)
- Extracorporeal urinary diversion (ECUD)
- International Robotic Cystectomy Consortium (IRCC).
- Body mass index [BMI],
- American Society of Anesthesiologists [ASA]
- Recurrence-free (RFS), disease specific (DSS) and overall survival (OS)
- Odds ratio [OR]
- 95% Confidence Interval [CI]