Abstract

Robot-assisted radical cystectomy is an alternative to the standard open surgical approach and has been increasingly used to surgically treat bladder cancer. Data on oncologic outcomes for the robotic approach have matured, and now intermediate and long-term oncologic outcomes are available. This review focuses on oncologic outcomes of the robotic approach with a focus on recent data and high-quality studies. Based on the current literature available, there are no consistent differences between the robotic and open approaches with respect to positive margin rates, lymph node yields, recurrence patterns, or recurrence free, cancer-specific, and overall survival. If oncologic surgical principles are adhered to, excellent oncologic outcomes are achievable with the robotic approach.

Keywords: Urinary bladder neoplasms, radical cystectomy, robotic radical cystectomy, oncologic outcomes, robotics, recurrence, survival

INTRODUCTION

Radical cystectomy and pelvic lymph node dissection is standard of care for surgically eligible patients with non-metastatic muscle-invasive bladder cancer, and is a preferred treatment for select patients with high risk of non-muscle invasive disease\(^1,2\). While open radical cystectomy has been the recognized gold standard for years, robot-assisted radical cystectomy (RARC) has become increasingly popular. Initially
described by Menon et al. in 2003, utilization of RARC increased from 0.7% in 2002 to 18.5% in 2012 in the United States. Advantages of the robotic approach relative to open radical cystectomy (ORC) include reduced blood loss, favorable transfusion rate and shorter length of stay.

Here, we review pertinent oncologic outcomes in the current RARC literature. We queried the PubMed electronic database in January 2021 for studies that report on oncologic outcomes for RARC. An emphasis was placed on randomized controlled trials, as well as contemporary comparative open approach cohorts, large single institution surgical series, multi-center initiatives and systematic reviews. A list of the major studies considered in this review is found in Table 1.

NODAL YIELD
Lower nodal yield and positive surgical margin status are independently associated with worse OS after adjustment for neoadjuvant chemotherapy and pathologic factors. In fact, nodal yields of 10-14 have been proposed as a marker of surgical quality, as patient, clinical and pathologic factors can influence lymph node yield. In a 2015 systematic review, Yuh et al. assessed 105 papers and found that median yield for a robotic approach was 19 lymph nodes (range: 3-55) with cumulative analyses finding no difference vs. ORC. Nodal yields are directly related to the surgical dissection template chosen, whether standard or extended. Among robotic surgeons, high volume surgeons and institutional volume were independently associated with performance of extended template dissections.

Several RCTs have found comparable nodal yields between RARC and ORC. Nix et al. found mean LN yields of 19 vs. 18 in RARC vs. ORC (P = 0.51) using a standard dissection template. In the largest clinical trial, RAZOR investigators found similar median lymph node yields of 23.3 for RARC with 51% utilizing an extended template, and 25.7 for ORC with 55% utilizing an extended template (P = 0.13). Other smaller RCTs reported similar findings. Several recent meta-analyses did not assess nodal yield.

Considering the abundance of data, adequate lymph node yields are achievable via robotic platforms, including extended and super extended templates. Maintenance of oncologic principles including performance of a meticulous dissection within pre-defined anatomic boundaries of a template appears to be more important than surgical approach.

POSITIVE MARGIN RATE
Positive surgical margin (PSM) rate is a measure of local disease burden, an independent predictor of survival, and can be a measure of surgical quality. Early criticism of minimally invasive approaches was that there was risk of higher positive margin rates in locally advanced tumors, as evidenced by a single non-controlled, non-comparative retrospective study. It was theorized that the lack of tactile feedback and learning curve was potential explanations. These early criticisms have largely been refuted. A systematic review showed that PSM rate was low in pT2 disease (< 1.5%) and 0%-25% in pT3 disease or higher, without any significant difference between ORC and RARC in a cumulative analysis of 17 studies. Interestingly, PSM did not appear to decrease with sequential case numbers or institutional volume, a finding that may reflect surgeons’ willingness to take on more difficult cases with experience. As a result of these early robotic data and historical open cystectomy series, acceptable PSM rates for robotic surgeons were proposed as < 3% for pT2, < 10% for pT3, < 25% for pT4 and < 7% overall.
Table 1. Selected studies evaluating oncologic outcomes after robot-assisted radical cystectomy

| Ref. | Year       | Comparison       | Study design | Setting   | Primary outcome | Pertinent secondary outcome(s) |
|------|------------|------------------|--------------|-----------|----------------|------------------------------|
|      |            |                  |              |           |                | TTR, PFS, OS                  |
|      |            |                  |              |           |                | Surgical margin, recurrence patterns |
|      |            |                  |              |           |                | RFS, CSS, OS, recurrence patterns |
|      |            |                  |              |           |                | Quality of life, Functional recovery |
|      |            |                  |              |           |                | Demographics, perioperative, pathologic results, narcotic use |
|      |            |                  |              |           |                | HRQOL, complications, clinical outcomes including surgical margin |
|      |            |                  |              |           |                | Surgical margin, lymph node yield |
|      |            |                  |              |           |                | Perioperative and pathologic outcomes |
|      |            |                  |              |           |                | Pathologic outcomes, overall survival |
|      |            |                  |              |           |                | Recurrence patterns, predictors of primary outcome |
|      |            |                  |              |           |                | Predictors of surgical margin status |
|      |            |                  |              |           |                | Complications, perioperative and pathologic outcomes |
|      |            |                  |              |           |                | Descriptors and predictors of robotic surgical approach |
|      |            |                  |              |           |                | Complications, perioperative and pathologic outcomes, recurrence |
|      |            |                  |              |           |                | Recurrence patterns, CSS, OS |
|      |            |                  |              |           |                | Primary outcome variables as predictors of survival |
|      |            |                  |              |           |                | Recurrence patterns at 2 years |
|      |            |                  |              |           |                | Surgical margin, lymph node yield |
|      |            |                  |              |           |                | Recurrence patterns, predictors of recurrent free survival |
|      |            |                  |              |           |                | Surgical margin, lymph node yield, predictors of survival |
|      |            |                  |              |           |                | Surgical margin, lymph node yield, predictors of survival |
Since then, multiple RCTs and retrospective comparative studies offer additional insight that robotic cystectomy can meet these standards of surgical quality. The RAZOR trial showed overall PSM rates of 5% (ORC) vs. 6% (RARC), \( P = 0.6 \) without any difference in pathologic stage between the groups. Of those with PSMs, 7/9 (78%) in RARC and 5/7 (71%) in ORC were T3 or above\(^6\). Two smaller RCTs also found no difference in PSM rate between open and robotic approaches\(^8,9\). A meta-analysis compiling 541 patients from RCTs showed no difference in PSM rates between RARC and ORC (RR = 1.2; 95%CI: 0.6-2.4)\(^{37}\). Additionally, one non-randomized comparative study found significantly increased PSM rate for ORC (18%) vs. RARC (6%) in an inversed probability weighted population despite similar pathologic staging, though when further specified by site of positive margin these results were not significantly different\(^{12}\). Multiple other non-randomized comparative studies have not found significant differences in PSM rate by approach\(^{13-17,19,20,22-24}\).

Collectively, the above data suggest favorable PSM rates are achievable via the robotic platform and are in alignment with standards of surgical quality set forth by best practices statements\(^{14}\). Regardless of surgical approach, the largest determinant of PSM rates is local disease stage.

**RECURRENCE PATTERNS**

Recurrence of bladder cancer after radical cystectomy is dependent on tumor and nodal stage, and ranges from 20% to 30% in pT2 disease, 40% for pT3, > 50% for pT4 and approximately 70% in pN1 disease or greater\(^{46}\). Other independent predictors of tumor recurrence include lymphovascular invasion and positive soft tissue margins\(^{49}\). Recurrences generally occur within the first 2-3 years and predict worse overall survival (OS)\(^{44}\).

Recurrence is generally classified as local, often referring to the cystectomy bed and within the pelvic lymph node template, or distant. Atypical patterns in MIS generally refer to peritoneal carcinomatosis, abdominal wall/port site metastases and extra pelvic lymph node recurrences, which have been described but are rare. In fact, a systematic review of 1094 studies found only 5 that reported port site metastasis\(^{46}\). Proposed contributors of atypical recurrence patterns in MIS include depressive local immunologic factors and/or enhanced tumor dissemination related to pneumoperitoneum, breach of oncologic operative principles,
Table 2. Oncologic outcomes from selected studies after robot-assisted radical cystectomy

| Ref. and study acronym | Year       | Surgical approach | Cases, (n) | PSM, n (%) | Lymph node yield, mean (SD) or median (IQR or range) | RFS          | CSS          | OS           |
|------------------------|------------|-------------------|------------|------------|---------------------------------------------------|--------------|--------------|--------------|
| Comparative studies, randomized |            |                   |            |            |                                                   |              |              |              |
| RAZOR trial, multiple authors\cite{6,7} | 2020, 2018 | ORC               | 152        | 7 (5)      | 25.7 (SD 14.5)                                   | 65%, 3 yr    | nr           | 69%, 3 yr    |
|                         |            | RARC              | 150        | 9 (6)      | 23.3 (SD 12.5)                                   | 68%, 3 yr    | nr           | 74%, 3 yr    |
| CORAL trial, Khan et al.\cite{8} | 2020       | ORC               | 20         | 2 (10)     | 18.5 (IQR 14-25)                                 | 60%, 5 yr    | 64%, 5 yr    | 55%, 5 yr    |
|                         |            | RARC              | 20         | 3 (15)     | 14.5 (IQR 11-21)                                 | 58%, 5 yr    | 68%, 5 yr    | 65%, 5 yr    |
|                         |            | LRC               | 19         | 1 (5)      | 15.5 (IQR 12-22)                                 | 71%, 5 yr    | 69%, 5 yr    | 61%, 5 yr    |
| Bochner et al.\cite{9}   | 2018       | ORC               | 58         | 3 (5)      | 29 (IQR 22-38)                                   | 59%, 5 yr    | 80%, 5 yr    | 65%, 5 yr    |
|                         |            | RARC              | 60         | 2 (3)      | 31 (IQR 23-37)                                   | 64%, 5 yr    | 75%, 5 yr    | 65%, 5 yr    |
| Parekh et al.\cite{10}   | 2012       | ORC               | 20         | 1 (5)      | 23 (IQR 15-28)                                   | nr           | nr           | nr           |
|                         |            | RARC              | 20         | 1 (5)      | 11 (IQR 9-22)                                    | nr           | nr           | nr           |
| Nix et al.\cite{11}      | 2010       | ORC               | 20         | 0 (0)      | 18 (range 8-30)                                  | nr           | nr           | nr           |
|                         |            | RARC              | 21         | 0 (0)      | 19 (range 12-30)                                 | nr           | nr           | nr           |
| Comparative studies, non-randomized |            |                   |            |            |                                                   |              |              |              |
| RACE study, Wijburg et al.\cite{12} | 2021       | ORC               | 168        | nr (18)*   | 13 (IQR 9-18)                                    | 75%, 1 yr    | nr           | nr           |
|                         |            | RARC              | 180        | nr (6)     | 15 (IQR 11-21)                                   | 76%, 1 yr    | nr           | nr           |
| Asil et al.\cite{13}     | 2021       | ORC               | 31         | 1 (3)      | 22 (nr)                                          | nr           | nr           | nr           |
|                         |            | RARC              | 61         | 9 (15)     | Range 22-25                                      | nr           | nr           | nr           |
| Ip et al.\cite{14}       | 2020       | ORC               | 159        | 23 (14)    | 20 (SD 14)*                                      | 75%, 5 yr    | nr           | 65%, 5 yr    |
|                         |            | RARC              | 73         | 8 (11)     | 12 (SD 8)                                        | 80%, 5 yr    | nr           | 70%, 5 yr    |
| Zhang et al.\cite{15}    | 2020       | ORC               | 272        | 22 (8)     | nr                                                | nr           | 55%, 5 yr    | nr           |
|                         |            | RARC              | 676        | 34 (5)     | nr                                                | nr           | 58%, 5 yr    | nr           |
| Faraj et al.\cite{16}    | 2019       | ORC               | 278        | 15 (5)     | 12 (IQR 9-18)*                                   | 63%, 10 yr   | nr           | 46%, 10 yr   |
|                         |            | RARC              | 203        | 7 (3)      | 18 (IQR 14-24)                                   | 70%, 10 yr   | nr           | 40%, 10 yr   |
| Moschini et al.\cite{17} | 2019       | ORC               | 1666       | 160 (10)   | 16 (10-24)                                       | nr           | nr           | nr           |
|                         |            | RARC              | 870        | 112 (13)   | 18 (12-25)                                       | nr           | nr           | nr           |
| Simone et al.\cite{18}   | 2018       | RARC, ICUD only   | 64         | 0 (0)      | 33.4 (SD 12.3)                                   | 79%, 4 yr    | 85%, 4 yr    | 82%, 4 yr    |
|                         |            | ORC               | 46         | 0 (0)      | 31.3 (SD 14.6)                                   | 73%, 4 yr    | 86%, 4 yr    | 80%, 4 yr    |
| Hanna et al.\cite{19}    | 2018       | ORC               | 7513       | (10.7)     | 12 (IQR 7-20)*                                   | 75%, 5 yr    | nr           | nr           |
|                         |            | RARC              | 2048       | (9.3)      | 17 (IQR 10-25)                                   | nr           | nr           | nr           |
| Gandagali et al.\cite{20} | 2016      | ORC               | 230        | 31 (13)    | 13 (IQR 9-17)                                    | 57%, 5 yr    | 62%, 5 yr    | 58%, 5 yr    |
|                         |            | RARC              | 138        | 12 (9)     | 12 (IQR 8-17)                                    | 54%, 5 yr    | 74%, 5 yr    | 59%, 5 yr    |
| Tan et al.\cite{21}      | 2016       | ORC               | 90         | 17 (19)*   | 12.6 (SD 10.9)                                   | 70%, 2 yr    | 81%, 2 yr    | 74%, 2 yr    |
| Study | Year | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 | Notes |
|-------|------|---------|---------|---------|---------|---------|---------|-------|
| Matulewicz et al. | 2016 | RARC | 94 | 6 (8) | 14.9 (SD 10.0) | 79%, 2 yr | 84%, 2 yr | 84%, 2 yr |
| Nguyen et al. | 2015 | ORC | 9639 | (13) | 11 (IQR 5-19)* | nr | nr | nr |
| | | RARC | 2397 | (11) | 16 (IQR 9-25) | nr | nr | nr |
| Atmaca et al. | 2015 | ORC | 120 | 15 (13)* | 20 (IQR 11-27) | 60%, 5 yr* | nr | nr |
| | | RARC | 263 | 16 (6) | 21 (IQR 13-28) | 70%, 5 yr* | nr | nr |
| Non-comparative studies | | | | | | | | |
| IRCC, Elsayed et al. | 2021 | RARC only | 2107 | nr | nr | 66%, 5 yr | nr | 60%, 5 yr |
| Brassetti et al. | 2020 | RARC, ICUD only | 113 | 9 (8) | 36 (IQR 28-45) | 58%, 5 yr | 61%, 5 yr | 54%, 5 yr |
| IRCC, Hussein et al. | 2019 | RARC only | 446 | 30 (7) | 14 (IQR 9-22) | 59%, 10 yr | 65%, 10 yr | 35%, 10 yr |
| ERUS, Collins et al. | 2017 | RARC, ICUD only | 717 | 34 (4) | 18 (IQR 13-25) | 75%, 2 yr | nr | nr |
| IRCC, Raza et al. | 2015 | RARC only | 702 | 55 (8) | 16 (IQR 10-24) | 67%, 5 yr | 75%, 5 yr | 50%, 5 yr |
| IRCC, Hellenthal, et al. | 2011 | RARC only | 527 | nr | 17.8 (range 0-68) | nr | nr | nr |
| IRCC, Hellenthal, et al. | 2010 | RARC only | 513 | 35 (6.8) | nr | nr | nr | nr |

*Visual estimate based on Kaplan Meier curves provided in paper (specific numbers not provided by reference in text). P < 0.05. PSM: Positive surgical margin; SD: standard deviation; IQR: interquartile range; RFS: recurrence free survival; CSS: cancer-specific survival; OS: overall survival; ORC: open radical cystectomy; RARC: robotic assisted radical cystectomy; LRC: laparoscopic radical cystectomy; nr: not reported; ICUD: intracorporeal urinary diversion; RAZOR: randomized open vs. robotic cystectomy; CORAL: controlled three-arm trial of open, robotic, and laparoscopic radical cystectomy; RACE: radical cystectomy evaluation; IRCC: International Robotic Cystectomy Consortium; ERUS: European Association of Urology Robotic Urology Section.

or variant lymphatic dissemination related to robotic technique\textsuperscript{23}.

Nguyen et al.\textsuperscript{23} reported atypical patterns of recurrence in a non-randomized single center comparative study of ORC vs. RARC, including higher incidence of peritoneal carcinomatosis (21% vs. 8%) and extra pelvic lymph node (23% vs. 15%) \textbf{[Table 3]}. However, the denominator of these estimated proportions was distant recurrences and not overall recurrence, as is typically reported. It was additionally notable that distant recurrences were not significantly different between the two approaches, and the authors noted that selection bias may have contributed to these findings. The same group published a follow up study consisting of 310 patients and found that predictors of distant recurrences, peritoneal carcinomatosis and extra pelvic lymph node metastases did not significantly differ and concluded that tumor biology is likely the chief influencer of atypical recurrence, not surgical approach\textsuperscript{46}. Bochner et al.\textsuperscript{9} later found that there was variation in location of recurrence and that RARC resulted in greater numbers of recurrences in the abdomen and pelvis. However, this only achieved significance when pooled and stratification of abdominal recurrences as separate from distant and local recurrences is controversial and of unclear clinical significance\textsuperscript{47}. Notably, the study was not powered to determine differences in patterns of recurrence.
| Ref. | Year       | Surgical approach | Cases (n) | Local recurrence*, n (%) | Distant recurrence*, n (%) | Peritoneal carcinomatosis, n (%) | Abdominal wall/port site, n (%) | Extra pelvic lymph nodes, n (%) | Significantly different? | Comments |
|------|------------|-------------------|-----------|--------------------------|---------------------------|----------------------------------|-------------------------------|-------------------------------|---------------------------|----------|
|      |            |                   |           |                          |                           |                                  |                               |                               |                           |          |
|      | Comparative studies, randomized | | | | | | | | | |
| RAZOR trial, multiple authors [6,7] | 2020, 2018 | ORC | 152 | 3 (2.0) | 25 (16.4) | 1 (0.7) | 1 (0.7) | 9 (5.9) | No | Largest RCT to date |
| RAZOR trial, multiple authors [6,7] | 2020, 2018 | RARC | 150 | 6 (4.0) | 22 (14.7) | 2 (1.3) | 0 | 9 (6.0) | |
| CORAL trial, Khan et al [8] | 2020 | ORC | 20 | 3 (15.0) | nr | nr | nr | nr | No | Small sample size. Distant recurrences reported in aggregate only, not shown here |
| CORAL trial, Khan et al [8] | 2020 | RARC | 20 | 3 (15.0) | nr | nr | nr | nr | |
| CORAL trial, Khan et al [8] | 2020 | LRC | 19 | 3 (15.7) | nr | nr | nr | nr | |
| Bochner et al [9] | 2018 | ORC | 58 | 5 (8.6) | 27 (46.6) | 2 (3.4) | 0 | 10 (17.2) | No | Not powered to detect differences in recurrence patterns |
| Bochner et al [9] | 2018 | RARC | 60 | 17 (28.3) | 20 (33.0) | 2 (3.3) | 5 (8.3) | 5 (8.3) | |
|      | Comparative studies, non-randomized | | | | | | | | | |
| Faraj et al [16] | 2019 | ORC | 278 | 19 (7) | 64 (23) | 5 (1.8) | 0 | 11 (4.0) | No | Large single institutional study |
| Faraj et al [16] | 2019 | RARC | 203 | 12 (6) | 40 (20) | 4 (2.0) | 0 | 4 (2.0) | |
| Tan et al [21] | 2016 | ORC | 90 | 17 (19) | 25 (28) | 3 (3) | 1 (1) | 2 (2) | No | Intracorporeal diversions in all robotic cases |
| Tan et al [21] | 2016 | RARC | 94 | 11 (12) | 8 (9) | 2 (2) | 1 (1) | 3 (3) | |
| Nguyen et al [22] | 2015 | ORC | 79 | 15/65 (23) | 26/73 (36) | 2/26 (8) | nr | 4/26 (15) | Yes | Denominator is distant recurrence, as listed in the reference |
| Nguyen et al [22] | 2015 | RARC | 158 | 24/136 (18) | 43/147 (29) | 9/43 (21) | nr | 10/43 (23) | |
|      | Non-comparative studies | | | | | | | | | |
| IRCC, Elsayed et al [26] | 2021 | RARC only | 2107 | 241 (11) | 382 (18) | 26 (1.2) | 25 (1.2) | 109 (5.2) | n/a | RARC not associated with different patterns or higher recurrence relative to historic ORC series |
| IRCC, Hussein et al [27] | 2019 | RARC only | 446 | 69 (15) | 97 (22) | 6 (1) | 5 (1) | 21 (5) | n/a | Analysis restricted to patients with > 10 years follow up |
| Collins et al [29] | 2017 | RARC, ICUD only | 717 | 78 (10.7) | 128 (17.8) | 5 (0.7) | 2 (0.3) | 47 (6.6) | n/a | Totally intracorporeal urinary diversion cohort |

*Local recurrence defined as any recurrence in the cystectomy bed or lymph node dissection template. *Distant recurrence defined as any recurrence which is not local or atypical. *Though sometimes reported in the referenced studies as a subset of distant recurrences, atypical recurrences reported here are mutually exclusive of local and distant recurrence. *The difference in local recurrence rates did not meet conventional levels of significance (sHR = 0.36; 95%CI: 0.11-1.12; P = 0.077). Similarly, the difference in the rate of abdominal recurrence did not reach statistical significance (sHR = 0.38; 95%CI: 0.07-1.96; P = 0.2). However, when the pelvic and abdominal recurrences were combined into a single group representing local/regional recurrence, the ORC group showed significantly less local/regional recurrence compared to RARC (sHR = 0.34; 95%CI: 0.12-0.93; P = 0.035).*
Multiple studies have since demonstrated that recurrence patterns do not differ by surgical approach. The RAZOR trial found no significant difference between ORC and RARC in recurrence patterns and showed low overall local recurrence rates (2% vs. 4%). Rare atypical recurrences were also observed in the ORC arm and did not differ between approaches[7]. A large non-randomized single center comparative study from Mayo Clinic in Arizona showed similar rates of local, distant and rare atypical recurrences[16]. An institutional report of ~180 cases, 90 of which were robotic with intracorporeal diversion, showed a low rate of atypical recurrences with no difference between surgical approaches[21]. An IRCC study of 2107 pts showed slightly higher local recurrence (11%, citing a greater percentage of extravesical disease and variant histology in their cohort) with atypical recurrence patterns similar to ORC series and those of the RAZOR trial[7,25]. A separate IRCC analysis found that tumor factors rather than those related to surgical approach were predictive of early recurrence after cystectomy and also showed that surgeons in their cohort reported a very low rate of divergence from oncologic principles[26]. Lastly, a large multi-institutional robotic cystectomy and totally intracorporeal urinary diversion cohort from the EAU Robotic Urology Section Scientific Working Group found that early recurrence rates and patterns appeared comparable to open series[29].

If oncologic principles are followed, these aggregate data suggest that atypical recurrence is exceedingly rare and are more likely reflective of tumor biology than surgical approach.

SURVIVAL OUTCOMES
The primary measure of treatment efficacy in radical cystectomy is survival, including recurrence-free, cancer-specific and overall survival[1]. Though reported here for reference, we would discourage direct comparison across studies as there is significant heterogeneity with respect to cancer variables (e.g., receipt of neoadjuvant chemotherapy, disease stage, and tumor histopathology), patient demographic and clinical characteristics, surgeon and institutional factors including intra-operative practices and post-operative follow up protocols, adjuvant therapies and length of follow up. This heterogeneity is reflected by a 2015 systematic review of mostly retrospective studies which demonstrated a wide range of 5-year survival estimates of DFS, CSS and OS between 53%-74%, 66%-80% and 39%-66%, respectively[33].

Several contemporary comparative studies do offer additional limited insight, though we are only aware of 3 RCTs that report survival outcomes. RAZOR is the largest RCT reporting survival outcomes at approximately 150 patients in each arm and reports 3 year outcomes[7]. RARC was similar compared with ORC in RFS (68% vs. 65%, P = 0.6) and OS (74% vs. 69%, P = 0.3). Bochner et al.[9] found that a median follow up of 4.9 years, no differences were observed in recurrence [hazard ratio (HR) = 1.27; 95%CI: 0.69-2.36; P = 0.4], cancer-specific survival (P = 0.4), or overall survival (P = 0.8). However, the authors cautioned that their study was not powered to assess survival outcomes. A meta-analysis with pooled data from these two studies found that RARC and ORC may result in similar time to recurrence (HR = 1.1; 95%CI: 0.8-1.4), but the evidence of certainty was low[10]. More recently, the CORAL study reported 5-year RFS, CSS, OS as well and found no differences in surgical approaches comparing open vs. robotic vs. laparoscopic approaches[8]. However, their study was limited by low sample size as only 20 patients were included in each arm and included high-risk non-muscle invasive bladder cancer.

Though lacking the rigor of a controlled trial, long-term oncologic outcomes from several robotic cohorts have recently become available. Faraj et al.[16] reported their 10 year survival outcomes in a single institution retrospective comparative study and found that RFS and OS were similar between ORC and RARC approaches (63% vs. 70%, P = 0.14 and 46% vs. 40%, P = 0.47 respectively). The cohorts were similar in cancer characteristics, patient demographics and clinical factors as well as intra operative practices.
Retrospective non-comparative results from the IRCC on patients with long-term follow up show RFS, CSS and OS at 10 years were 59%, 65% and 35%, consistent with historical ORC and MIS cohorts\cite{27}. Not surprisingly, in multivariable models, they found that survival was associated with age, positive margins, tumor/nodal stage, and adjuvant treatments. Similar results are described in a multicenter study among RARC patients with totally intracorporeal urinary diversion\cite{26}. A single institutional comparative study also showed similar survival in a totally intracorporeal urinary diversion robotic cohort when compared with ORC\cite{18}.

Matured, long-term survival data from randomized controlled studies, including RAZOR, are further anticipated. Early and intermediate survival outcomes between RARC and ORC appear to be similar. Since no consistent difference in PSM rates or recurrence patterns have been found in the literature, we expect long-term survival differences to be driven largely by factors related to disease aggressiveness including stage and need for adjuvant therapies, rather than surgical approach.

**FUTURE PERSPECTIVES**

Nearly 20 years after the robotic approach to radical cystectomy was described\cite{3}, RARC remains an effective and minimally invasive option for patients undergoing cystectomy that can achieve oncologic outcomes that are comparable to the gold standard open approach. Evidence-based consensus and best practices on RARC are available\cite{34}.

There are no absolute contraindications to the robotic approach, but an early learning curve is recognized and several challenging case scenarios (e.g., large bulky tumors, history of pelvic radiation) should be preferentially managed by experienced robotic surgeons. RARC can be safely utilized in the octogenarian\cite{48}, and oncologic outcomes are excellent in sex-sparing techniques in the female patient\cite{49} as well as male patient\cite{50}. Excellent pathologic outcomes have been described for aggressive histopathological variants which are known to present with higher tumor stage\cite{51}. The usage of the robotic approach to cystectomy will continue to increase as urologic surgeons become more experienced and comfortable with the platform and education becomes more commonplace in residency training programs\cite{4}.

Though the current evidence is well-supported, it is limited by the lack of large, randomized controlled trials. We eagerly anticipate more mature, high-quality data comparing oncologic outcomes of open and robotic cystectomy. Robot-assisted radical cystectomy with intracorporeal urinary diversion vs. open radical cystectomy (iROC) is a multicenter prospective RCT in England randomizing 320 patients to iRARC or ORC. Accrual finished in February 2020, and oncologic outcomes of interest include atypical recurrence patterns, survival, as well as outcomes related to surgeon fatigue, cost-effectiveness and patient quality of life\cite{52}.

**CONCLUSION**

Surgical quality indicators, including lymph node yield and positive surgical margin rate, are comparable between ORC and RARC. Despite an early case series of atypical recurrence patterns, contemporary comparative studies, including the largest randomized controlled trial, as well as a multi-institutional retrospective robotic cohort of > 2000 consecutive patients, show this is a rare occurrence and not associated with surgical approach. Survival outcomes appear to be similar as well, including long term survival from several comparative and non-comparative reports. Ultimately, surgeon comfort with the selected approach and adherence to oncologic principles is more important than the approach itself.
DECLARATIONS

Authors’ contributions
Made substantial contributions to conception and design of the study and performed data acquisition and interpretation: Miller BL, Lau CS, Pachorek M, Yuh B, Sam AP
Performed data acquisition, as well as provided administrative, technical, and material support: Miller BL, Lau CS, Pachorek M

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Not applicable.

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Conflicts of interest
All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate
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