

Oncologic and Perioperative Outcomes of Robot-Assisted Versus Open Radical Cystectomy with Consideration of Neoadjuvant Chemotherapy in Muscle-Invasive Bladder Cancer: A Systematic Review and Meta-Analysis

Vladimir Yu. Startsev^{1*}, Sergey V. Sarychev² and Nutsalkhan G. Gasanov³

¹Department of Urology, Department of Oncology, St. Petersburg State Pediatric Medical University, Ministry of Health of the Russian Federation, St. Petersburg, Russia

²Department of Urology, Hospital Maennedorf, Zürich, Switzerland

³Head, "Republican Oncology Center", Makhachkala, Republic of Dagestan

***Corresponding Author:** Sergey Sarychev, Department of Urology, Hospital Maennedorf, Zürich, Switzerland.

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Abstract

Background

The comparative oncologic effectiveness of robot-assisted radical cystectomy (RARC) versus open radical cystectomy (ORC) for muscle-invasive bladder cancer (MIBC) remains debated, particularly in the context of contemporary multimodal treatment including neoadjuvant chemotherapy (NAC). Randomized trials have demonstrated non-inferiority of RARC for progression-free survival, whereas long-term overall survival (OS) data remain limited.

Objective

To systematically assess oncologic and perioperative outcomes of ORC versus RARC in MIBC, with consideration of NAC, and to perform a quantitative synthesis of OS.

Methods

A systematic search of PubMed/MEDLINE, Scopus, and Web of Science was conducted up to January 31, 2026, without time restrictions. Comparative studies reporting oncologic outcomes (OS, PFS, CSS) were included. Randomized trials were evaluated using RoB 2, and observational studies using the Newcastle–Ottawa Scale. A random-effects meta-analysis (Der Simonian–Laird) was performed for OS.

Results

Randomized trials confirmed oncologic non-inferiority of RARC compared with ORC. Pooled analysis of two adjusted comparative cohorts demonstrated that RARC—particularly when performed with intracorporeal urinary diversion—was associated with improved OS compared with ORC (HR 0.72; 95% CI 0.60–0.87; $I^2 = 0\%$). RARC consistently reduced estimated blood loss and transfusion rates while maintaining comparable rates of major complications.

Conclusion

RARC demonstrates oncologic equivalence to ORC in MIBC and may be associated with improved OS in comparative real-world analyses. Further long-term randomized data are needed to clarify potential survival differences and interactions with NAC.

Keywords

Robot-Assisted Versus; Neoadjuvant Chemotherapy; Muscle-Invasive Bladder Cancer; Meta-Analysis.

Introduction

Bladder cancer (BC) is recognized as one of the most common malignancies worldwide [1]. According to WHO data, in 2022 BC ranked second in incidence among onco-urological malignancies after prostate cancer, ninth overall in cancer incidence ($n = 614,298$), and thirteenth in cancer-related mortality ($n = 220,596$), despite advances in diagnostic and therapeutic technologies [2,3].

Approximately one quarter of BC cases present with muscle invasion of the bladder wall (MIBC), requiring radical treatment (radical cystectomy, RC, or radiation therapy, RT) or, in selected cases, palliative approaches in combination with systemic therapy (chemotherapy and/or immunotherapy) [3]. Tumor invasion into the muscular layer significantly reduces both quality of life and overall survival [4]. Approximately half of patients with MIBC die from complications related to metastatic progression [5], and five-year mortality following radical cystectomy approaches 50–70% [6]. Controlling the aggressive biological behavior of this tumor remains a major global challenge.

After neoadjuvant chemotherapy (NAC), radical cystectomy with pelvic lymph node dissection is considered the standard treatment for eligible patients with MIBC, as it plays a critical role in survival and prevention of local and distant recurrence [3,7]. This “gold standard” procedure remains technically complex, with a substantial learning curve, and requires careful risk stratification to reduce postoperative morbidity. Over the past two decades, robot-assisted radical cystectomy (RARC) has emerged as a minimally invasive alternative aimed at reducing perioperative morbidity while maintaining oncologic efficacy.

Despite widespread adoption of robotic surgery, the comparative oncologic safety of RARC versus ORC remains debated. Randomized trials have demonstrated non-inferiority of RARC with respect to progression-free survival (PFS); however, long-term overall survival (OS) data remain limited. In parallel, increasing use of intracorporeal urinary diversion (ICUD) and contemporary multimodal treatment strategies, including NAC, further complicate interpretation of outcomes. Patient age, comorbidities, and surgical technique may influence both surgical and oncologic outcomes and correlate with readmission rates [8]. The choice of urinary diversion after RARC remains an area of ongoing scientific debate [9].

The objective of this systematic review and meta-analysis was to evaluate oncologic and perioperative outcomes of RARC versus ORC in patients with MIBC, with specific consideration of NAC and the role of intracorporeal diversion, and to perform a quantitative synthesis of overall survival where appropriate.

Methods

Search strategy

The review was conducted in accordance with the PRISMA 2020 statement. A systematic literature search was performed in PubMed/MEDLINE, Scopus, and Web of Science up to January 31, 2026, without time restrictions. Only English-language studies were included.

Search terms combined the following concepts: “robot-assisted radical cystectomy” OR RARC; “open radical cystectomy” OR ORC; “overall survival” OR “cancer-specific survival” OR “progression-free survival”; “propensity score” OR “randomized”; and “muscle-invasive bladder cancer.” Additional keywords included radical cystectomy, robot-assisted surgery, open radical cystectomy, and oncologic outcomes (OS, PFS, CSS).

Reference lists of relevant articles were manually screened. No time restrictions were applied. Grey literature was not included. The protocol was developed prior to data extraction but was not prospectively registered in PROSPERO.

Screening

- Records screened (title/abstract): 713
- Records excluded: 658
- Studies included in qualitative synthesis: 6 [12–17]
- Studies included in quantitative synthesis (meta-analysis of OS): 2
- Full-text articles assessed for eligibility: 55
- Full-text articles excluded: 51

Reasons for exclusion

- Not comparative ORC vs RARC (n = 18)
- No OS/PFS/CSS reported (n = 14)
- Non-MIBC or mixed metastatic cohorts (n = 8)
- Overlapping populations (n = 6)
- Case series with <100 patients (n = 5)

Eligibility Criteria

Inclusion criteria

- MIBC (cT2–T4a, M0)
- Comparative ORC vs RARC
- Reported oncologic outcomes (OS, PFS, CSS)
- Randomized trials or adjusted observational studies (propensity score matching or multivariable Cox regression)
- Median follow-up ≥ 3 years (except non-inferiority RCTs)

Exclusion criteria

Narrative reviews; case series with <100 patients; non-comparative studies; NMIBC-only cohorts; biomarker-only studies.

Statistical analysis

Overall survival (OS) was quantified using hazard ratios (HRs) with 95% confidence intervals. The meta-analysis included studies in which OS HRs were reported based on multivariable Cox regression models or propensity score matching.

A random-effects model (Der Simonian–Laird) was used as the primary analytical approach due to expected clinical and methodological heterogeneity (different countries, study designs, proportions of ICUD/ECUD, etc.). Statistical heterogeneity was assessed using the I^2 statistic and Cochran’s Q test.

The primary OS analysis included two independent comparative studies:

- A population-based national study using propensity score matching
- A single-center comparative study using a multivariable Cox model

Limitations

Only two studies were included in the pooled OS analysis. Both were observational in design, and residual confounding cannot be excluded. No formal GRADE assessment was performed. Publication bias testing was not conducted due to the limited number of included studies. Additional search methods included manual screening of reference lists and review articles.

Results

Study selection

A total of 1,027 records were identified (PubMed: 312; Scopus: 428; Web of Science: 287). After removal of 314 duplicates, 713 records underwent title and abstract screening. Fifty-five full-text articles were assessed for eligibility. Fifty-one were excluded for predefined reasons, leaving six studies for qualitative synthesis and two for quantitative OS meta-analysis.

Oncologic Outcomes

Randomized trials: key data

In a meta-analysis of two comparative studies, overall survival was higher with robot-assisted cystectomy—particularly when intracorporeal urinary diversion was performed—compared with open cystectomy (pooled HR 0.72; 95% CI 0.60–0.87; $I^2 = 0\%$) (Tables 1 and 2).

Study	Design	N (Total)	RARC (n)	ORC (n)	NAC (%)	Median Follow-up	Primary Oncologic Endpoint
Parekh et al. (RAZOR)	RCT	302	150	152	21%	36 months	2-year PFS
Catto et al. (iROC)	RCT	338	169	169	18%	24 months	Days alive out of hospital; PFS
Khetrapal et al.	RCT meta-analysis	6 RCTs	—	—	variable	—	OS, PFS
Mortezavi et al.	Nationwide PSM cohort	3169	934	2235	32%	49 months	OS
Murthy et al.	Multivariable cohort	614	307	307	28%	44 months	OS

Table 1: Characteristics of included comparative studies. Study design, sample size, surgical approach, follow-up duration, neoadjuvant chemotherapy rates, and primary oncologic endpoints.

Study	Tool	Randomization	Allocation Concealment	Blinding	Confounding Control	Overall Risk
RAZOR	RoB 2	Low risk	Low risk	High (open-label)	NA	Low risk
iROC	RoB 2	Low risk	Low risk	High (open-label)	NA	Low risk
Mortezavi	NOS	NA	NA	NA	Propensity matching	Moderate
Murthy	NOS	NA	NA	NA	Multivariable Cox	Moderate

Table 2: Risk-of-bias assessment. Randomized trials were assessed using RoB 2; observational studies were assessed using the Newcastle–Ottawa Scale.

Outcome	RARC	ORC	Effect Estimate
Overall Survival (pooled)	—	—	HR 0.72 (95% CI 0.60–0.87; $I^2=0\%$)
Estimated Blood Loss	↓	—	–322 mL (RCT meta-analysis)
Transfusion Rate	Lower	Higher	OR 0.43
Major Complications	Comparable	Comparable	No significant difference
Operative Time	Longer	Shorter	+45–60 min

Table 3: Key perioperative and oncologic outcomes. Summary of hazard ratios, confidence intervals, and perioperative metrics across the included studies.

- RAZOR trial [12]
- n = 302; Phase III non-inferiority design.
- Primary endpoint: 2-year PFS.

Results

Two-year PFS was comparable (non-inferior) between RARC and ORC. No significant difference in OS was observed. RARC was associated with lower blood loss but longer operative time. Complication rates were comparable. Oncologic equivalence of RARC was demonstrated for the first time in a randomized setting iROC trial [13]

- n = 317; intracorporeal RARC (iRARC).
- Primary endpoint: DAOH-90 (days alive and out of hospital within 90 days).

Results

More days alive and out of hospital were observed after RARC. Severe complications were reduced. No differences in oncologic outcomes were detected. This was the first large RCT focusing specifically on intracorporeal diversion.

Quantitative Synthesis of Overall Survival

Two independent adjusted comparative studies were eligible for pooled OS analysis:

- Nationwide Swedish cohort [15]: HR 0.71 (95% CI 0.56–0.89)
- Multivariable cohort [16]: HR 0.74 (95% CI 0.53–1.00)
- The pooled random-effects estimate demonstrated:
- HR 0.72 (95% CI 0.60–0.87; $I^2 = 0\%$).

This suggests that RARC, particularly when performed with intracorporeal diversion, was associated with improved overall survival compared with ORC in real-world comparative cohorts. Interpretation should account for the observational design and potential residual confounding.

Intracorporeal vs. Extracorporeal Urinary Diversion in RARC

Technique evolution

The first robot-assisted radical cystectomies were performed with extracorporeal urinary diversion (eRARC), in which resection was performed robotically, whereas construction of an ileal conduit or orthotopic neobladder was completed through a Mini laparotomy. With increasing experience and technical refinement, intracorporeal diversion (iRARC) has become more widely adopted, allowing the entire procedure to be performed intraperitoneally using robotic techniques.

According to data from the International Robotic Cystectomy Consortium (IRCC), by 2018 more than 90% of RARCs in specialized centers were performed with intracorporeal diversion.

Randomized data

The iROC trial [13] evaluated intracorporeal urinary diversion (n = 317). The primary endpoint was DAOH-90.

Results

A longer duration alive and out of hospital was observed after iRARC. Severe complications were reduced. No differences in oncologic outcomes were identified. This was the first large RCT to demonstrate the clinical benefits of a fully intracorporeal robotic approach.

A meta-analysis by Katayama et al. (2021) [17] demonstrated lower blood loss with iRARC, reduced postoperative pain and ileus rates, and comparable oncologic outcomes. Importantly, these differences were most pronounced in high-volume, experienced centers.

Potential mechanisms underlying the advantages of iRARC include:

- Avoidance of extended laparotomy
- Reduced trauma to the anterior abdominal wall
- Reduced bowel exposure to the external environment
- Earlier patient mobilization

Limitations of iRARC

- High dependence on surgeon experience
- Significant learning curve
- Longer operative time during the initial implementation phase
- Need for procedural centralization

Currently, iRARC should be considered the most advanced form of robotic cystectomy. However, its advantages are primarily realized in high-volume centers. Despite advances in intracorporeal urinary diversion, postoperative ileus remains a significant complication following iRARC with ICUD.

Independent predictors of complications after iRARC include [18]:

- G-8 score: OR ~0.63, p ≈ 0.004
- Time to mobilization: OR ~2.36, p ≈ 0.004
- Time to oral fluid intake: OR ~3.39, p ≈ 0.002
- Duration of bowel reconstruction: OR ~1.03, p ≈ 0.04

According to Zennami et al. [18], postoperative ileus (POI) after ICUD has a multifactorial etiology; strict implementation of ERAS components, early mobilization, and early nutrition are critical preventive measures.

Radical Cystectomy in Elderly Patients

Relevance of the problem

The median age of patients with MIBC exceeds 70 years. Up to 40% of patients over 75 years of age do

not receive radical treatment due to concerns about surgical morbidity [9]. Chronological age per se is not a contraindication to radical cystectomy; however, physiological reserve varies substantially among individuals.

Perioperative risks in elderly patients include:

- Reduced cardiorespiratory reserve
- Sarcopenia
- Polymorbidity
- Increased risk of venous thromboembolism (VTE)
- Increased risk of postoperative delirium [18]

Thirty- and 90-day mortality after radical cystectomy in patients over 75 years ranges from 5% to 10%, depending on center volume and patient selection.

Impact of Surgical Technique in the Elderly

Several observational studies demonstrate reduced blood loss with RARC, lower transfusion rates, and faster recovery compared with ORC. Of particular relevance is the reduction in VTE incidence (OR 1.84 in favor of RARC) [14,20], which may be especially important in geriatric patients.

Frailty screening using the G-8 tool may help identify patients at increased risk of gastrointestinal complications after ICUD [18].

Oncologic outcomes in adequately selected elderly patients show OS and PFS comparable to younger cohorts; functional status, rather than chronological age, appears to be the key determinant of outcomes.

The contemporary approach [14] includes assessment of multiple parameters to guide surgical decision-making:

- Comprehensive Geriatric Assessment (CGA)
- Frailty assessment
- Charlson Comorbidity Index
- Sarcopenia index

Practical conclusions

1. Age >75 years is not an absolute contraindication to radical cystectomy or ERAS-based perioperative management.
2. Minimally invasive techniques may provide particular benefit in patients with limited physiological reserve.
3. Decision-making should occur within a multidisciplinary team.
4. Centralization of treatment is especially important for elderly patients.

Retrospective analyses have shown that early rehabilitation parameters (time to mobilization and initiation of oral fluid intake) and geriatric screening using the G-8 scale are associated with the risk of postoperative ileus; a G-8 threshold ≤ 13 demonstrated moderate predictive ability (AUC 0.716) [16].

These findings emphasize the importance of strict ERAS implementation and careful frailty assessment when planning surgical management.

Role of Neoadjuvant Chemotherapy

Neoadjuvant cisplatin-based chemotherapy (NAC) represents the current standard of care for eligible patients with MIBC and is recommended by major international guidelines prior to radical cystectomy [3,8,11]. Across included comparative cohorts, the proportion of patients receiving NAC varied, reflecting real-world practice patterns.

Although the present analysis was not powered to perform a formal interaction analysis (NAC × surgical approach), available evidence suggests that the oncologic safety of RARC is maintained within contemporary multimodal treatment frameworks.

Future studies should investigate whether surgical approach modifies the survival benefit associated with NAC.

Randomized Controlled Trials

Razor trial [12]

- **Randomization process:** low risk of bias (randomization procedure and group balance were clearly described).
- **Deviations from intended interventions:** some risk (blinding was not feasible due to the nature of the surgical intervention).
- **Missing outcome data:** low to moderate risk (per-protocol analysis and complete outcome reporting were provided; minor deviations are possible due to protocol exceptions). Outcome measurement: low risk (hard clinical endpoints).
- **Selection of reported results:** low risk (pre-specified primary non-inferiority endpoint).
- **Summary:** The overall risk of bias for key oncologic outcomes was low to moderate, mainly due to the open-label design and per-protocol analysis.

Systematic reviews of RCTs (Prisma-level appraisal)

The analyses by Catto J.W.F. (2022) and Khetrapal et al. (2023) [13,14] confirm the consistency of randomized evidence. However, for the quantitative synthesis of primary OS data in the present review, only original comparative studies were included to avoid double counting of patients.

Observational Comparative Studies (Newcastle–Ottawa Scale Assessment)

Swedish nationwide cohort [15]

- **Selection:** high (nationwide registry with clear definition of intervention groups).
- **Comparability:** high (propensity score matching combined with regression adjustment; sensitivity analyses performed).
- **Outcome:** high (OS as a hard endpoint; adequate follow-up duration).
- **Main sources of potential bias:** residual confounding (confounding by indication), inter-center variability, and possible incompleteness of certain clinical variables.

Murthy Bet al. [16]

- **Selection:** moderately high (large single-center cohort, but limited external validity).
- **Comparability:** moderate (multivariable adjustment performed; no propensity score matching).
- **Outcome:** high (time-to-event OS analysis).
- **Main sources of potential bias:** treatment selection influenced by clinical factors and learning curve stage (confounding by indication); center-specific characteristics.

Overall, RCTs provide low-risk evidence for oncologic endpoints, with inherent limitations related to the open-label design. Observational studies demonstrate strong outcome validity but remain susceptible to residual confounding and institutional variability.

Current Guidelines (EAU, AUA, NCCN) for the Management of MIBC**EAU (European association of urology)**

The EAU recommends radical cystectomy with pelvic lymph node dissection and urinary diversion as the standard surgical treatment for MIBC, emphasizing timely surgery (delay >3 months is associated with worse OS) [19].

Key EAU recommendations [24]

1. Indications for RC: pT2–T4a, N0M0 (and selected very high-risk NMIBC).
2. Lymph node dissection should be performed as an integral part of RC; standard LND is recommended.
3. Center volume: at least 20 RC procedures per hospital per year are recommended, supporting centralization.
4. Elderly patients: RC may be considered in selected patients over 80 years.
5. Urinary diversion: choice of diversion should not compromise oncologic control.
6. Extended thromboprophylaxis reduces postoperative VTE risk.

The EAU framework emphasizes timing, center experience, standardized reporting, and adherence to oncologic principles, aligning with the ORC/RARC and iRARC/eRARC comparisons presented above.

AUA/ASCO/ASTRO/SUO (United States)

US guidelines recommend radical cystectomy with bilateral pelvic lymph node dissection as the standard treatment for surgically fit patients with non-metastatic MIBC (M0).

Recent AUA-related publications acknowledge robotic cystectomy as a valid surgical option, provided that oncologic quality indicators (adequate lymph node dissection, negative margins, complication control) are maintained.

Practical conclusion: The AUA position supports comparison based on surgical quality and outcomes rather than surgical access (open vs robotic) per se [19].

NCCN (United states)

The NCCN endorses a multimodal approach to MIBC: cisplatin-based NAC followed by radical cystectomy

for eligible patients, or bladder-preserving trimodality therapy in selected cases [19].

The NCCN patient guidelines emphasize radical cystectomy as a cornerstone of treatment, with systemic therapy administered preoperatively when appropriate.

Practical conclusion: The NCCN framework directly supports the structure of the present review, which integrates surgical technique and the role of NAC.

Discussion

Various urinary diversion options include orthotopic neobladder reconstruction (e.g., Studer or Padovan techniques) and heterotopic diversion (e.g., Bricker ileal conduit) [21]. After any type of urinary diversion, careful correction of metabolic acidosis and preservation of renal function (GFR \geq 50 ml/min) are essential in the postoperative period [22]. Risk of vitamin B12 deficiency following ileal resection must also be considered [20].

Long-term follow-up after radical cystectomy with orthotopic diversion is associated with substantial complication rates, which may affect quality of life and survival [23]. Complications include procedure-related adverse events [24], and quality-of-life issues encompass physical, emotional, social, and functional domains in patients with MIBC [25].

Minimally invasive approaches require a steep Trendelenburg position, which may affect respiratory physiology (e.g., changes in PaCO₂ and respiratory rate). However, these approaches are consistently associated with reduced blood loss, lower transfusion requirements, fewer perioperative complications, and faster recovery of bowel function compared with open surgery [26].

When comparing intracorporeal and extracorporeal urinary diversion, debate persists. Data from the International Robotic Cystectomy Consortium (IRCC) demonstrated that iRARC was associated with reduced operative time (357 vs 400 minutes), lower blood loss (300 vs 350 ml), and fewer transfusions (4% vs 19%, $p < 0.001$). Early series showed higher severe complication rates with iRARC (13% vs 10%, $p = 0.02$); however, complication rates declined substantially over time as experience increased (from 95% to 3%, $p < 0.001$) [27,28].

Multivariable analysis identified increasing annual case volume (OR 1.02; 95% CI 1.01–1.03; $p < 0.002$), later time period (2013–2016: OR 0.68; 95% CI 0.44–1.05; $p < 0.001$), and ASA score < 3 (OR 1.75; 95% CI 1.38–2.22; $p < 0.001$) as factors associated with successful iRARC adoption [27,28].

In a multicenter analysis of 948 patients (ORC = 272; iRARC = 301; eRARC = 375), Zhang et al. (2020) reported reduced blood loss ($p < 0.001$), shorter hospitalization ($p < 0.001$), and lower rates of intestinal obstruction ($p = 0.023$) after iRARC compared with eRARC and ORC [29]. Severe 90-day complications (Clavien–Dindo III–V) were lower in the iRARC group (16.9% vs 24.8% vs 26.1%; $p = 0.015$). Predictors of major complications included age and Charlson comorbidity index [29].

Data from the Asian Robot-Assisted Radical Cystectomy Consortium (RARCEC) also suggest advantages of

intracorporeal neobladder in terms of reduced blood loss, faster recovery, and shorter hospital stay [30]. Although early reports indicated higher severe complication rates with iRARC, these differences diminished with increasing surgical experience.

Long-term urinary reservoir function, erectile function, and continence outcomes remain areas of ongoing investigation in the international literature [31]. New evidence continues to emerge regularly.

Principal findings

In this systematic review and quantitative synthesis of comparative studies, RARC—particularly when performed with intracorporeal urinary diversion—was associated with improved overall survival compared with ORC (pooled HR 0.72; 95% CI 0.60–0.87; $I^2 = 0\%$). Randomized evidence confirms at least oncologic non-inferiority of RARC in terms of 2-year PFS, with no evidence of inferior local or systemic disease control.

Overall Survival (Pooled Analysis)

The quantitative OS synthesis included

- Swedish nationwide cohort (PSM) [15]: HR for OS 0.71 (95% CI 0.56–0.89) for RARC vs ORC. Murthy et al. [16]: HR for OS 0.74 (95% CI 0.53–1.00) for iRARC vs ORC; eRARC vs ORC: HR 1.10 (95% CI 0.82–1.40).
- Interpretation: In pooled analysis, iRARC was associated with approximately a 28% relative reduction in mortality compared with ORC. However, several limitations must be acknowledged:
- Only two studies were included.
- Study designs differed (PSM-based national registry vs single-center multivariable Cox model).
- In Murthy et al. [16], the upper confidence interval reached 1.00, indicating borderline statistical significance.

Random-effects pooled estimate

The pooled random-effects model demonstrated superiority of the robotic approach (iRARC subgroup) in terms of OS compared with ORC (HR 0.72; 95% CI 0.60–0.87; $I^2 = 0\%$). No statistically significant heterogeneity was detected.

The pooled HR <1.0 suggests an association between iRARC and improved OS in real-world practice. However, interpretation must consider that the meta-analysis included only two observational studies with statistical adjustment, and residual confounding cannot be excluded.

Importantly, randomized data confirm oncologic comparability between robotic and open cystectomy for key endpoints (2-year PFS, non-inferiority design), with no evidence of inferior disease control [12].

In a meta-analysis of two comparative cohorts ($n \approx 4,085$), RARC with emphasis on intracorporeal diversion was associated with improved OS compared with ORC (pooled HR 0.72; 95% CI 0.60–0.87; $I^2 = 0\%$). However, randomized data do not demonstrate superiority of the robotic approach in 2-year PFS. Therefore, the overall evidence base supports oncologic equivalence with a possible survival advantage in real-world settings.

Interpretation of the survival signal

Interestingly, while the RAZOR RCT [12] demonstrated non-inferiority but not superiority of RARC, national observational data [15] showed reduced overall mortality with the robotic approach.

Several factors may contribute to this signal:

- Reduced blood loss and transfusion rates
- Reduced VTE incidence (as suggested in RCT-level synthesis)
- Faster postoperative rehabilitation
- Concentration of robotic programs in high-volume centers

Overall survival represents a hard endpoint and likely reflects not only oncologic control but also perioperative mortality and major complication rates.

Role of Intracorporeal Urinary Diversion

Stratification of the robotic cohort into eRARC and iRARC demonstrated that potential OS benefit was observed in the intracorporeal subgroup (HR 0.74), whereas extracorporeal robotic technique did not demonstrate improvement compared with ORC [16].

This finding may suggest that the full clinical benefits of robotic cystectomy are realized primarily when the procedure is performed in a fully minimally invasive format.

Perioperative advantages of RARC are consistently replicated in randomized and population-based studies:

- Significant reduction in blood loss
- Lower transfusion rates
- Shorter hospital stays Comparable rates of severe complications

Even modest reductions in severe perioperative complications may translate into measurable survival benefit.

Elderly patients and frailty

The perioperative advantages of RARC may be particularly relevant in elderly and frail patients. Reduced blood loss, lower VTE risk, and faster mobilization are clinically meaningful in patients with limited physiological reserve.

However, surgical decision-making should prioritize functional status rather than chronological age. Frailty screening tools, including the G-8, Charlson Comorbidity Index, and CGA, should be incorporated into preoperative assessment.

Centralization and learning curve

RARC remains a technically demanding procedure with a substantial learning curve. Part of the observed survival benefit may reflect treatment centralization in high-volume centers, were

- Lymph node dissection is standardized

- ERAS protocols are implemented
- Technical consistency is maintained
- Multidisciplinary perioperative care is optimized

Therefore, the apparent advantage of RARC may partially represent a center-volume effect rather than solely a surgical access effect.

Strengths

1. Inclusion of both RCT-level evidence and national registry data
2. Quantitative synthesis of overall survival
3. Dedicated analysis of intracorporeal diversion
4. Consideration of geriatric and frailty aspects

Limitations

1. OS meta-analysis based on only two observational studies
2. Potential residual confounding
3. Lack of long-term OS data from large RCTs
4. Heterogeneity in ERAS implementation and perioperative protocols
5. Learning curve effects difficult to quantify

Clinical implications

The combined evidence suggests that RARC—particularly when performed with intracorporeal diversion—is an oncologically safe alternative to ORC, with potential survival benefits in real-world practice.

When selecting surgical approach, the following factors should be considered:

- Center experience and surgical volume
- Adequate lymph node dissection
- Margin status
- Frailty assessment
- ERAS adherence

Future directions

Future research should focus on:

- Large randomized trials with long-term OS endpoints
- Standardized stratification of eRARC vs iRARC
- Formal interaction analyses between NAC and surgical approach
- Integration of frailty-based models into surgical selection algorithms

Conclusions

Radical cystectomy with lymph node dissection remains the standard of care across major guidelines (EAU, AUA, NCCN). Cisplatin-based NAC is recommended for most eligible patients as part of multimodal therapy prior to surgery.

The choice of surgical approach (ORC vs RARC) should be evaluated through the lens of oncologic safety and adherence to established surgical quality standards rather than the surgical access itself.

The RAZOR trial demonstrated non-inferiority of RARC compared with ORC for 2-year PFS. National registry data demonstrate comparable oncologic control while enabling assessment of real-world long-term outcomes, thereby strengthening external validity.

RARC provides consistent perioperative benefits (reduced blood loss and transfusion rates, often shorter hospitalization) with comparable rates of severe complications. Intracorporeal urinary diversion represents a technological maturation of the robotic approach.

In elderly patients, selection should be based on functional reserve rather than chronological age. Guidelines explicitly state that cystectomy may be considered even in patients over 80 years, provided adequate selection criteria are met. Minimally invasive approaches may be particularly advantageous in selected older patients due to perioperative benefits.

Overall, when performed in experienced high-volume centers adhering to oncologic principles and ERAS protocols, RARC can be considered a preferred minimally invasive approach in appropriately selected patients with MIBC.

Declarations

- **Funding:** The authors received no external funding for this study.
- **Conflict of Interest:** The authors declare no conflicts of interest related to this work.
- **Ethical Approval:** Not applicable. This study is a systematic review and meta-analysis of previously published studies.

Data availability

All data used in this study are available from the corresponding published articles. The extracted datasets and statistical code are available from the corresponding author upon reasonable request.

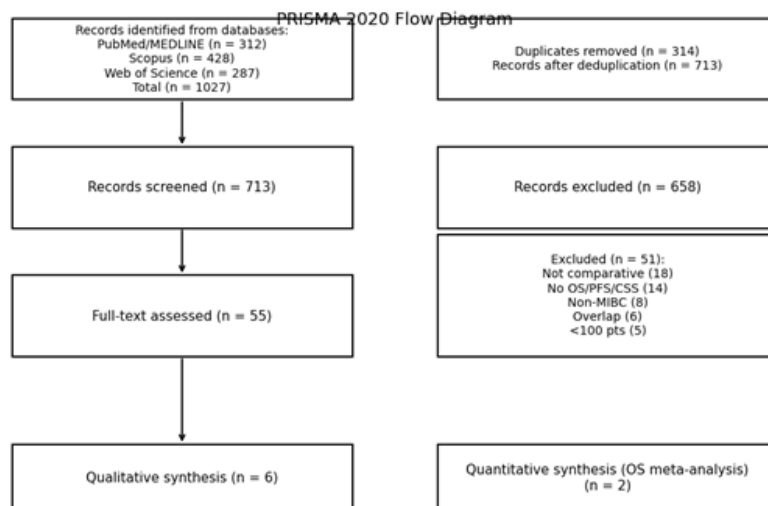


Figure 1: PRISMA 2020 flow diagram. Flow diagram illustrating the study selection process for qualitative synthesis and quantitative meta-analysis.

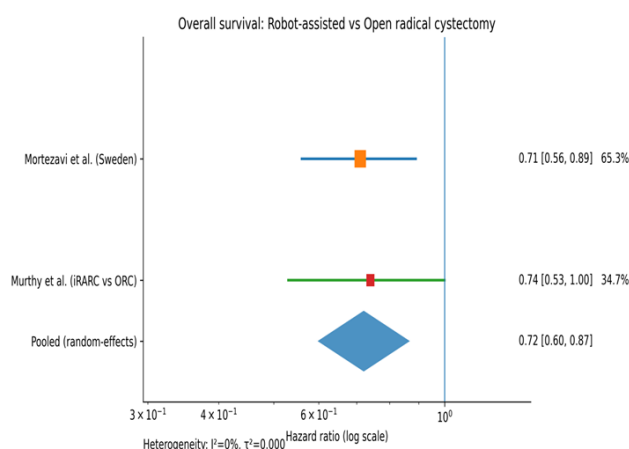


Figure 2: Forest plot of overall survival. Random-effects meta-analysis of adjusted hazard ratios comparing robot-assisted radical cystectomy versus open radical cystectomy. Squares represent study-specific estimates (size proportional to weight), and the diamond represents the pooled estimate (HR 0.72; 95% CI 0.60–0.87; $I^2 = 0\%$).

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