

Enhanced Recovery Pathways After Robot-Assisted Urological Surgery

Abstract

Robot-assisted urological surgery has reduced surgical trauma, but the quality of postoperative recovery still depends on coordinated perioperative care. Enhanced recovery pathways combine patient preparation, standardized anesthesia, fluid stewardship, opioid-sparing analgesia, early nutrition, mobilization, and explicit discharge criteria. This review critically synthesizes evidence published from 2020 to 2025 on enhanced recovery after robot-assisted radical prostatectomy, radical cystectomy, partial nephrectomy, and related renal surgery. A structured narrative approach was used, prioritizing comparative studies, randomized trials, prospective cohorts, systematic reviews, and contemporary implementation studies with verifiable digital object identifiers. Across procedures, the most consistent benefits are earlier mobilization, faster gastrointestinal recovery, shorter hospitalization, reduced unnecessary tubes and intravenous therapy, and greater feasibility of same-day or early discharge without a clear increase in major complications or readmissions in appropriately selected patients. Benefits are most pronounced when baseline care is heterogeneous or recovery is intrinsically complex, as after radical cystectomy. In mature prostatectomy programs, enhanced pathways increasingly function as reliability systems rather than dramatic length-of-stay interventions, and recent randomized evidence suggests diminishing incremental gains when standard care is already optimized. For renal surgery, evidence is promising but less extensive. The central implication is that enhanced recovery should be treated as a procedure-specific, adherence-sensitive clinical system rather than a fixed checklist. Future work should emphasize patient-reported recovery, risk-adapted discharge, equitable follow-up, and standardized reporting of pathway compliance and outcomes.

Keywords: enhanced recovery; robotic surgery; urology; radical prostatectomy; radical cystectomy; partial nephrectomy; same-day discharge; perioperative care

1. Introduction

Robotic platforms have transformed urological surgery by allowing complex extirpative and reconstructive procedures to be performed through minimally invasive access. Yet the robotic approach alone does not determine recovery. Postoperative pain, nausea, fluid imbalance, delayed gastrointestinal function, deconditioning, catheter and drain management, anxiety about self-care, and variation in discharge practice can still prolong hospitalization or trigger unplanned health-care use.

Enhanced recovery pathways address these problems by organizing multiple evidence-based actions across the preoperative, intraoperative, and postoperative phases rather than relying on one technical intervention [1]. Their relevance is therefore particularly strong in robotic urology, where reduced incision-related trauma creates an opportunity for rapid functional recovery but only if perioperative care is aligned with that physiological advantage.

The evidence base is uneven across procedures. Radical cystectomy has the longest history of formal enhanced recovery pathways because bowel manipulation, urinary diversion, major fluid shifts, thromboembolic risk, and postoperative ileus create a complex recovery profile. Meta-analytic evidence published in 2020 associated enhanced pathways after cystectomy with shorter hospital stay and earlier gastrointestinal recovery, although effects on major complications and readmission were less consistent [2,6]. Radical prostatectomy has a lower postoperative burden, and contemporary robotic programs increasingly target discharge on postoperative day zero or one. A 2020 meta-analysis of enhanced recovery after radical prostatectomy found shorter stay and earlier return of gastrointestinal and ambulatory function [3], while subsequent same-day discharge studies show that carefully selected patients can leave hospital safely on the day of surgery [7,8]. Robot-assisted partial nephrectomy and other renal procedures have a smaller evidence base, but comparative work suggests that structured recovery protocols can shorten stay without clearly increasing readmission or complications [4,9].

A further issue is that the meaning of “enhanced recovery” has changed. Earlier programs often compared a bundled pathway with highly variable conventional care. Contemporary control groups may already receive short fasting, multimodal analgesia, early feeding, early mobilization, restrictive fluid practice, and streamlined catheter management. Consequently, newer trials can show smaller differences even when the pathway remains clinically useful as a mechanism for reliability, coordination, and audit. A contemporary 2025 study of robot-assisted radical cystectomy illustrates this principle: adherence to at least 12 of 15 pathway items was associated with a shorter postoperative stay and fewer serious complications than lower adherence [5]. The important question is therefore no longer whether enhanced recovery “works” in the abstract, but which elements add value for each robotic procedure, how adherence modifies outcomes, and how pathways should evolve when optimized care becomes routine.

61 **2. Aim, objectives and review methodology**

62 The aim of this review is to evaluate contemporary enhanced recovery pathways after robot-
63 assisted urological surgery and to distinguish procedure-specific benefits from general improvements
64 in modern perioperative practice. Four objectives guided the synthesis: to identify the recovery
65 elements with the clearest physiological and clinical rationale; to compare outcomes across robot-
66 assisted prostate, bladder, and renal surgery; to examine the influence of pathway adherence, patient
67 selection, and institutional maturity; and to define research priorities relevant to high-quality robotic
68 programs.

69 A structured narrative review method was used. Literature published from January 2020 through
70 December 2025 was identified through targeted PubMed/MEDLINE searches and cross-checking of
71 journal and DOI records. Search concepts combined terms for enhanced recovery, fast-track care,
72 perioperative pathways, same-day discharge, robotic surgery, prostatectomy, cystectomy, partial
73 nephrectomy, analgesia, fluid therapy, prehabilitation, complications, readmission,
74 length of stay, and patient-reported recovery. Priority was given to adult studies of robot-assisted
75 urological procedures, including randomized trials, prospective or retrospective comparative cohorts,
76 systematic reviews, meta-analyses, and implementation studies. Studies of open urological surgery
77 were retained when they addressed a pathway component, such as goal-directed fluid therapy, that
78 directly informs robotic pathways and when equivalent robotic evidence remained limited. Broader
79 perioperative evidence was used sparingly for mechanistic context rather than as a substitute for
80 urology-specific outcomes.

81 Eligible evidence had to report clinically interpretable outcomes such as length of stay,
82 mobilization, return of bowel function, oral intake, pain or opioid exposure, complications,
83 readmission, emergency attendance, patient satisfaction, quality of life, pathway adherence, or
84 oncological follow-up. Pediatric surgery, non-urological procedures without a directly transferable
85 pathway question, conference-only records, non-verifiable citations, and publications outside the
86 2020-2025 window were excluded from the reference set. Thirty sources were retained for the final
87 synthesis, each with a verifiable DOI. Because the literature is heterogeneous in procedure, pathway
88 composition, discharge culture, and outcome definitions, pooled effect estimates were not
89 recalculated. Instead, findings were compared by clinical domain and procedure, with emphasis on
90 direction and consistency of effect, methodological strength, and the distinction between statistical
91 significance and practical recovery benefit.

Critical appraisal focused on whether study design matched the recovery outcome, comparator care was contemporary, and effects could reflect selection or treatment-era bias. Randomized evidence was weighted most heavily for individual interventions, while comparative cohorts informed real-world feasibility, discharge failure, and safety events. Systematic reviews identified cross-study signals but were interpreted cautiously when pathway definitions or surgical approaches differed. No study was treated as proof that every bundle component was effective. Where findings conflicted, the synthesis considered baseline length of stay, discharge criteria, adherence, sample size, and procedure complexity. This approach preserved clinically important heterogeneity rather than concealing it within a pooled estimate overall.

3. Architecture of an enhanced recovery pathway

Enhanced recovery begins before admission. The most transferable element is expectation setting: patients need a clear account of expected pain, mobility, oral intake, catheter or stoma care, discharge timing, warning symptoms, and access to post-discharge advice. Education reduces uncertainty and converts discharge from an administrative event into a planned clinical milestone. This is particularly important when the patient will manage a urinary catheter after prostatectomy or a stoma after cystectomy. Prehabilitation extends this preparation by identifying reversible deficits in exercise capacity, nutrition, anemia, smoking, alcohol use, and psychological readiness. Contemporary urologic oncology literature increasingly treats prehabilitation as a bridge between diagnosis and surgery rather than an optional fitness program [25]. The strongest rationale is in older, frail, malnourished, or highly comorbid patients, although protocols remain heterogeneous and the optimal duration is unresolved.

Nutrition and fasting strategies aim to minimize catabolism while preserving anesthetic safety. Modern pathways avoid unnecessarily prolonged fasting, encourage timely postoperative oral intake, and use individualized nutritional support where malnutrition is present. Carbohydrate drinks are incorporated in many pathways, but their incremental benefit depends on patient factors and local anesthetic practice. The principle is less about a single beverage than about preventing avoidable dehydration and metabolic stress. Medication review, venous thromboembolism prevention, antimicrobial planning, and control of diabetes, hypertension, and anemia should occur before the day of surgery. For same-day discharge pathways, logistical screening is equally important: responsible adult support, travel time, communication access, health literacy, and willingness to recover at home may be as decisive as age or tumor characteristics.

123 Intraoperative care should protect the physiological reserve created by minimally invasive surgery.
124 Robotic procedures often involve steep Trendelenburg positioning, pneumoperitoneum, prolonged
125 anesthesia, and procedure-specific fluid constraints. Fluid management should therefore pursue
126 euvolemia rather than reflexive restriction or liberal replacement. In a randomized cystectomy trial,
127 goal-directed fluid therapy did not simply eliminate postoperative ileus, underscoring that
128 hemodynamic algorithms are not independent of the wider pathway and patient context [17]. The
129 practical objective is to avoid both tissue edema from excess fluid and organ hypoperfusion from
130 under-resuscitation, while using vasopressors and balanced fluids rationally. Normothermia,
131 prophylaxis for postoperative nausea and vomiting, lung-protective ventilation, and efficient reversal
132 of neuromuscular blockade all support early oral intake and mobilization.

133 Pain management is another central domain. The goal is not opioid elimination at any cost, but
134 adequate analgesia with the lowest exposure necessary to permit breathing, movement, sleep, and
135 gastrointestinal recovery. Multimodal regimens commonly combine acetaminophen, non-steroidal
136 anti-inflammatory drugs when renal function and bleeding risk allow, local anesthetic techniques, and
137 selective adjuncts. Evidence across surgical populations shows that completely opioid-free anesthesia
138 has not consistently produced clinically important reductions in postoperative pain or opioid use and
139 may introduce other adverse effects [18]. Robotic urology therefore favors opioid-sparing, patient-
140 specific strategies rather than doctrinaire avoidance. This distinction is supported by procedure-
141 specific evidence: a 2025 randomized trial in robot-assisted cystectomy found that a single
142 intraoperative dose of methadone did not reduce 24-hour opioid requirements compared with
143 morphine [29].

144 Postoperative recovery depends on removing barriers to function. Nasogastric tubes should not be
145 maintained routinely when they are unnecessary; intravenous fluids should be stopped once oral
146 intake is adequate; nausea should be treated promptly; and mobilization should begin within hours
147 rather than days. Early feeding is especially important after cystectomy, where delayed bowel
148 recovery has historically prolonged hospitalization. Catheters and drains require procedure-specific
149 plans rather than automatic removal schedules. A drain that does not change management can impede
150 movement, while premature catheter removal after reconstruction can create avoidable complications.
151 Enhanced recovery therefore does not mean “remove everything early”; it means that every device
152 should have an explicit indication and discontinuation criterion.

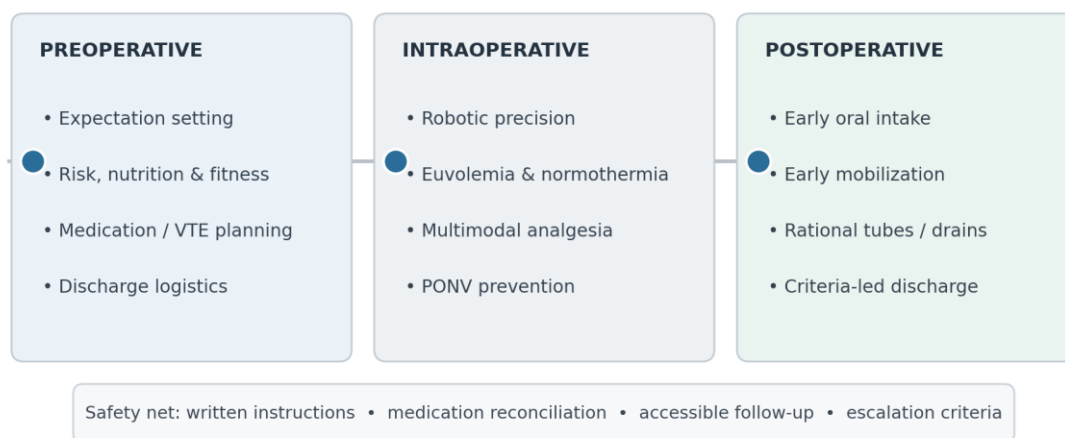
153 Discharge is the final pathway phase, not its endpoint. Same-day discharge after selected robotic
154 procedures shifts observation from the ward to the home environment, so safety depends on structured

155 follow-up. Successful programs combine objective discharge criteria with written instructions, direct
156 contact routes, medication plans, hydration advice, catheter education, and early telephone or
157 electronic review. The relevant outcome is not simply a shorter length of stay but a stable transition
158 without preventable emergency attendance, readmission, unmanaged pain, or patient distress. This
159 broader definition helps explain why enhanced recovery should be evaluated using patient-reported
160 physical recovery and care burden in addition to traditional surgical complications.

161 Discharge planning should begin before surgery and use functional rather than purely temporal
162 criteria. A patient is ready for home when able to mobilize safely, tolerate oral fluids and food, control
163 pain and nausea with oral medication, understand catheter, drain, or stoma care when relevant, and
164 recognize symptoms requiring urgent review. Physiological stability remains essential, but laboratory
165 testing should be targeted to procedure and individual risk rather than automatic. A rapid pathway also
166 requires a reliable safety net: written instructions, medication reconciliation, a telephone contact,
167 planned follow-up, and clear responsibility for abnormal symptoms. These safeguards are especially
168 important after day-zero discharge because complications are not prevented by leaving hospital early;
169 they must be detected and managed promptly. Follow-up quality is therefore an integral pathway
170 component.

Enhanced recovery pathway across the perioperative episode

A functional sequence linking preparation, intraoperative reliability and recovery at home



171
172 *Figure 1. Procedure-agnostic architecture of an enhanced recovery pathway, emphasizing functional*
173 *milestones and post-discharge safety.*

Domain	Core action	RARP emphasis	RARC emphasis	Renal emphasis	Outcome to audit
Education & expectation setting	Explain recovery milestones, self-care, warning signs and contact routes.	Catheter care and continence expectations.	Stoma/diversion education and bowel recovery.	Bleeding/hematuria, activity and renal follow-up.	Education completion; confidence; unplanned contacts.
Risk optimization	Assess nutrition, anemia, frailty, smoking, comorbidity and social support.	Select SDD candidates; functional readiness.	Higher prehabilitation need because of surgical burden.	Account for CKD and tumor/procedure complexity.	Optimization actions completed; pathway eligibility.
Fasting & nutrition	Avoid unnecessary fasting; resume appropriate oral intake early.	Rapid oral hydration and diet.	Nutrition support and early feeding are central.	Hydration balanced with renal/cardiovascular risk.	Time to oral intake; nausea; IV-fluid duration.
Fluid & temperature	Maintain euvoemia and normothermia; avoid routine overload.	Supports early ambulation/discharge.	Particularly important with bowel manipulation and longer procedures.	Protect perfusion while avoiding excess fluid.	Fluid balance; AKI; hypotension; hypothermia.
Analgesia & PONV	Use multimodal, opioid-sparing analgesia with risk-based antiemetics.	Oral regimen should be adequate for SDD.	Pain control must facilitate breathing, mobility and bowel recovery.	Avoid analgesic choices that compromise renal function.	Pain scores; opioid exposure; PONV; sedation.

Domain	Core action	RARP emphasis	RARC emphasis	Renal emphasis	Outcome to audit
Mobilization	Mobilize early with explicit functional targets.	Independent ambulation before discharge.	Progressive mobilization despite higher burden.	Ambulation paired with bleeding/hemodynamic assessment.	Time to ambulation; falls; functional recovery.
Devices	Remove IV therapy, drains and tubes when no longer indicated.	Streamline drains; planned urinary catheter strategy.	Individualize stents, drains and diversion devices.	Drain strategy linked to urine-leak/bleeding risk.	Device days; infections; reinterventions.
Discharge & follow-up	Use physiological + functional criteria and a reliable safety net.	Day-zero/day-one pathway where appropriate.	Usually staged; self-care competence essential.	SDD or early discharge only with renal-specific surveillance criteria.	Discharge failure; ED visits; readmission; QoR.

175

176 4. Robot-assisted radical prostatectomy

177 Robot-assisted radical prostatectomy is the clearest example of pathway maturation. By 2020,
178 pooled evidence already suggested that enhanced recovery programs shortened hospitalization and
179 accelerated flatus, ambulation, defecation, and drain removal compared with conventional pathways
180 [3]. At the same time, high-volume robotic practice was moving beyond “early discharge” toward
181 same-day discharge. In a multi-institutional French study of 358 planned same-day cases, discharge
182 failure was 4.2%, the 30-day complication rate was 16.8%, and readmission was 2.8%; lymph-node
183 dissection increased the risk of discharge failure, while pain at discharge was associated with
184 readmission [7]. These findings shifted attention from whether day-zero discharge is technically
185 possible to how candidate selection and perioperative symptom control determine success.

186 Subsequent studies across different health systems reached a similar conclusion. A comparative
187 2021 cohort found no clear safety penalty for same-day management when patients were selected
188 within a structured pathway [8]. Canadian and Australian experiences demonstrated feasibility with
189 low acute-care use and high satisfaction, while also showing that patient acceptance, first-case
190 scheduling, travel distance, and home support influence actual discharge success [13,14]. A 2024
191 series of 224 multiport procedures reported that most eligible patients could be discharged on the day
192 of surgery under an established enhanced recovery protocol [19]. One-year follow-up data from
193 another program did not identify a delayed safety signal that would argue against carefully designed
194 same-day pathways [20]. National database analysis has since documented increasing same-day use
195 without evidence that the shift inherently increases short-term mortality or readmission [26], and
196 contemporary reviews now treat same-day discharge as an emerging standard for appropriately
197 selected patients rather than an experimental endpoint [27].

198 The strongest caution is that length of stay has a floor effect. Once standard care already delivers
199 early feeding, early mobilization, limited opioids, prompt catheter education, and discharge within
200 approximately one to two days, an enhanced pathway may have little room to shorten hospitalization
201 further. The first randomized trial specifically testing an enhanced protocol against optimized
202 contemporary care in robot-assisted prostatectomy illustrates this point. Enhanced care accelerated
203 autonomous mobilization, but did not significantly reduce postoperative hospitalization, oral nutrition
204 time, 30-day complications, or overall quality-of-life domains [30]. This does not invalidate the
205 pathway; it changes the interpretation of benefit. In mature programs, the pathway functions as a
206 reliability framework that reduces unwarranted variation and supports consistent discharge readiness
207 rather than as a mechanism for progressively shorter stays.

208 Patient-reported outcomes reinforce that distinction. A 2025 prospective cohort found that
209 enhanced recovery was associated with a smaller decline in physical well-being one month after
210 robot-assisted prostatectomy [28]. Recovery should therefore be measured beyond bed-days. Pain
211 control, fatigue, confidence with catheter care, continence expectations, sleep, return to normal
212 activity, and the number of post-discharge contacts all matter. Same-day discharge is most defensible
213 when it is an outcome of good recovery rather than a target imposed independently of recovery.
214 Programs should consequently maintain an overnight pathway for patients with uncontrolled
215 symptoms, late operating-room completion, hemodynamic concerns, limited support, or patient
216 preference.

217 5. Robot-assisted radical cystectomy

218 Radical cystectomy remains the procedure in which enhanced recovery has the greatest potential
219 absolute impact because surgical stress is high and recovery is multidimensional. The operation
220 combines pelvic extirpation, bowel use for urinary diversion, prolonged anesthesia, thromboembolic
221 risk, fluid shifts, stoma or neobladder education, and a substantial baseline risk of ileus and
222 complications. A 2020 individual-patient-data meta-analysis found that implementation of enhanced
223 recovery pathways was associated with shorter hospitalization after cystectomy, although protocols
224 and reporting varied substantially [2]. A separate 2020 meta-analysis of randomized trials similarly
225 found shorter stay, earlier first flatus, and earlier return to regular diet without a significant increase in
226 major complications, readmission, ileus, wound infection, or mortality [6]. These results support the
227 pathway as a recovery system while also showing that not every component produces an
228 independently measurable effect.

229 Robotic surgery may amplify some pathway benefits by reducing incision-related trauma and
230 blood loss, but the surgical approach and the recovery program should not be conflated. In a
231 prospective case-control analysis, robot-assisted cystectomy within a fast-track program was
232 associated with greater protocol adherence, earlier mobilization, and a higher composite recovery
233 success rate than open surgery [10]. A 2023 institutional study similarly reported earlier oral intake
234 and bowel recovery, fewer episodes of postoperative ileus, shorter hospitalization, and lower non-
235 surgical medical costs after implementation of robot-assisted cystectomy with a comprehensive
236 pathway [16]. The mechanism is probably additive: minimally invasive surgery reduces one
237 component of physiological injury, while the pathway controls fluids, analgesia, gastrointestinal
238 stimulation, mobilization, education, and device management.

239 The contemporary 2025 cohort provides a useful adherence analysis. Eighty patients undergoing
240 robot-assisted cystectomy with urinary diversion were classified according to completion of 15
241 pathway elements. Patients completing at least 12 elements had a median postoperative stay of 19
242 rather than 24 days, fewer serious complications, and less postoperative ileus than the lower-
243 adherence group [5]. The study cannot establish that adherence alone caused the outcome differences
244 because treatment era, intracorporeal diversion, surgeon experience, and other unmeasured factors can
245 travel with higher compliance. Nevertheless, it supports a central implementation principle: pathway
246 labels are less informative than actual delivery. An institution can claim to use enhanced recovery
247 while achieving little benefit if carbohydrate loading, mobilization, oral intake, antiemetic
248 prophylaxis, fluid goals, education, or opioid-sparing analgesia are inconsistently implemented.

249 Urinary diversion technique adds another layer. Comparative evidence indicates that intracorporeal
250 diversion can reduce blood loss and transfusion and may support faster recovery in selected settings,
251 although complication profiles and learning-curve effects remain relevant [12]. Three-year
252 randomized data comparing totally intracorporeal robot-assisted cystectomy with open surgery
253 support oncological comparability while showing perioperative advantages for the robotic strategy in
254 experienced hands [22]. Updated expert recommendations therefore increasingly integrate the surgical
255 approach with modern recovery principles rather than treating them as separate domains [23]. The
256 practical lesson is not that every patient requires an identical robotic reconstruction, but that operative
257 technique, surgeon experience, and pathway design should be evaluated together when interpreting
258 recovery outcomes.

259 Long-term oncological claims require more caution. Enhanced recovery plausibly reduces
260 inflammation, complications, immobility, and delay in adjuvant therapy, all of which could influence
261 downstream cancer care. A 2021 systematic review across cancer surgery found no convincing
262 evidence that enhanced recovery compromises long-term oncological outcomes and suggested
263 possible benefit in some settings [11]. In cystectomy, a large 2024 observational analysis found
264 shorter hospitalization with enhanced recovery but no clear independent effect on long-term
265 oncological outcomes [21]. The 2025 adherence cohort reported better overall survival in the high-
266 adherence group without a significant difference in progression-free survival [5], but residual
267 confounding makes causal interpretation inappropriate. Enhanced recovery should therefore be
268 justified primarily by perioperative quality, not by an unproven direct antitumor effect.

269 Analgesic refinement also demonstrates why individual pathway components need testing. Opioid
270 exposure after cystectomy can impair bowel function and increase nausea, but replacing one opioid
271 with another long-acting agent is not automatically beneficial. In the randomized methadone trial,
272 postoperative opioid requirements were similar to morphine despite high patient satisfaction in the
273 methadone arm [29]. More broadly, observational comparisons of robotic and open cystectomy show
274 differences in opioid prescribing and perioperative morbidity, but such findings are influenced by
275 surgical approach, institutional prescribing culture, and patient selection [24]. Current practice is best
276 served by multimodal analgesia, avoidance of unnecessary opioid escalation, and repeated assessment
277 of whether analgesia is enabling mobility and oral intake.

278 **6. Robot-assisted partial nephrectomy and other renal surgery**

279 Evidence for renal robotic surgery is less extensive than for prostatectomy or cystectomy, but the
280 direction of findings is consistent. A 2021 comparative study of an enhanced program after robot-
281 assisted partial nephrectomy reported that more than 80% of pathway patients were discharged by
282 postoperative day two, with faster return of bowel function and no significant increase in
283 complications or readmission [9]. This is clinically plausible because partial nephrectomy combines
284 limited incisions with concerns about hemorrhage, urine leak, renal function, nausea, and pain; a
285 structured pathway can accelerate recovery while preserving observation criteria for these specific
286 risks.

287 Same-day discharge has also been explored. A 2023 study of robot-assisted partial nephrectomy
288 found comparable readmission and emergency-visit rates between same-day and inpatient
289 management and lower overall cost, although same-day care increased post-anesthesia unit time and
290 unplanned office contacts [15]. Those trade-offs are important: reduced inpatient utilization does not
291 eliminate care; it redistributes care toward recovery units, telephone support, and outpatient review.
292 Institutions should therefore measure total resource use rather than interpreting a shorter admission as
293 an automatic efficiency gain.

294 Broader implementation data covering nephrectomy and robot-assisted prostatectomy further
295 suggest that enhanced protocols can reduce mean length of stay without an obvious increase in short-
296 term adverse outcomes [4]. However, renal pathways should remain diagnosis- and procedure-
297 specific. Radical nephrectomy, partial nephrectomy, and complex reconstruction differ in bleeding
298 risk, renal functional priorities, drain use, and pain burden. Same-day discharge should be based on
299 stable hemoglobin when clinically indicated, controlled pain and nausea, oral intake, mobilization,
300 voiding or catheter plans, and reliable access to urgent reassessment. The research priority is now
301 prospective validation of standardized renal pathways, particularly in patients with chronic kidney
302 disease, higher tumor complexity, or major comorbidity.

303 Renal surgery requires recovery criteria that protect organ-specific outcomes. Hemodynamic
304 stability must be interpreted alongside bleeding risk, urine output, renal function, and possible delayed
305 hematuria or urine leak. Prolonged drainage or repeated laboratory testing can delay discharge without
306 benefit, but removal of monitoring is equally inappropriate. A pathway should define findings that
307 trigger hemoglobin or creatinine measurement, imaging, continued drainage, or overnight observation.
308 After partial nephrectomy, patients need concise advice about hydration, analgesia, activity
309 restrictions, hematuria, fever, flank pain, and when to seek urgent assessment. This is selective de-

intensification: low-risk patients avoid unnecessary hospital care while higher-risk patients receive surveillance without being labelled pathway failures.

Procedure-specific evidence landscape

The same recovery principles have different evidence maturity and clinical priorities by procedure



Figure 2. Procedure-specific evidence maturity and dominant recovery priorities across robot-assisted prostate, bladder and renal surgery.

Table 2. Representative contemporary evidence informing enhanced recovery after robot-assisted urological surgery.

Study	Procedure design /	Sample	Principal recovery finding	Interpretation
Zhao et al. (2020) [3]	Radical prostatectomy; systematic review/meta-analysis	7 trials; 784	Shorter stay, earlier ambulation, flatus and defecation with enhanced care.	Supports recovery acceleration; component heterogeneity limits attribution.
Ploussard et al. (2020) [7]	RARP; multi-institutional SDD cohort	358	SDD failure 4.2%; 30-day readmission 2.8%.	Shows routine SDD feasibility within a coordinated pathway.

Study	Procedure design /	Sample	Principal recovery finding	Interpretation
Pierquet et al. (2025) [30]	RARP; randomized trial	129	Faster autonomous mobilization, but no reduction in hospitalization or 30-day complications.	Illustrates a ceiling effect when standard care is already optimized.
Williams et al. (2020) [2]	Radical cystectomy; systematic review/IPD meta-analysis	22 studies; 4,048	Enhanced pathways associated with shorter hospitalization; outcomes varied by pathway content.	Strongest mature evidence base in complex urological recovery.
Zhang et al. (2020) [6]	Radical cystectomy; RCT meta-analysis	7 RCTs; 813	LOS MD -1.12 days; earlier flatus and regular diet; no significant rise in major complications/readmission.	Supports faster gastrointestinal and hospital recovery without clear safety penalty.
Schiavina et al. (2021) [10]	RARC vs open within enhanced pathway; prospective case-control	147	Robotic approach associated with higher pathway adherence and recovery trifecta achievement.	Surgical approach and pathway delivery interact.
Nakamura et al. (2023) [16]	RARC/enhanced pathway vs open historical care	Retrospective cohort	Earlier oral intake/bowel recovery, lower ileus and shorter stay in robotic pathway group.	Large bundled effect; treatment-era and approach effects cannot be separated fully.

Study	Procedure design /	Sample	Principal recovery finding	Interpretation
Kitamura et al. (2025) [5]	RARC; adherence cohort	80	High adherence associated with LOS 19 vs 24 days and fewer serious complications.	Reinforces compliance as a meaningful exposure, while causality remains limited.
Dominique et al. (2021) [9]	RAPN; comparative enhanced pathway cohort	162	80.4% of pathway patients discharged by POD2; no significant rise in complications/readmission.	Supports early discharge after renal robotic surgery.
Wood et al. (2023) [15]	RAPN; SDD vs inpatient comparison	192	Comparable readmission/emergency visits and lower overall cost with SDD; more PACU time/office contacts.	Shorter admission can shift rather than eliminate resource use.

317

318 7. Implementation, limitations and future directions

319 The major implementation challenge is variation hidden behind a common label. Two enhanced
320 recovery programs may share only a fraction of their components, and the same written protocol can
321 produce different outcomes depending on adherence. Future studies should therefore report both
322 pathway content and compliance at patient level. The 2025 urology evidence assessment identified
323 strong support for many familiar elements, including education, multimodal analgesia, early
324 mobilization, early feeding, and structured fluid management, while also emphasizing variable
325 evidence quality across components [1]. For clinical governance, a small set of auditable measures is
326 preferable to a long checklist that is rarely reviewed. Examples include preoperative education
327 completed, appropriate fasting, multimodal analgesia delivered, nausea prophylaxis, mobilization
328 within a defined interval, oral intake target achieved, unnecessary intravenous fluids stopped, and
329 documented discharge criteria.

330 Patient selection must also move from exclusion by age to risk-adapted planning. Older adults may
331 benefit most from avoiding hospitalization-related sleep disruption and deconditioning, yet they may
332 also have frailty, cognitive vulnerability, or limited social support. Prehabilitation literature in
333 urologic oncology argues for assessment of functional reserve rather than simple demographic
334 thresholds [25]. Similarly, same-day discharge data show that non-medical factors such as distance,
335 caregiver availability, health literacy, and confidence affect success. A pathway that shortens stay
336 only for patients living close to tertiary centers could unintentionally widen access disparities. Remote
337 follow-up, regional partnerships, transport planning, and explicit escalation routes should therefore be
338 considered part of pathway design.

339 Outcome selection should become more patient-centered. Length of stay is easy to measure but
340 increasingly insensitive in mature robotic programs. Future trials should prioritize days alive and at
341 home, quality of recovery, physical well-being, sleep, nausea burden, opioid exposure, time to normal
342 activity, catheter or stoma confidence, emergency contacts, caregiver workload, readmission, and total
343 episode cost. The prostatectomy quality-of-life findings show that a pathway can produce a
344 meaningful physical recovery benefit even when hospitalization is already short [28]. Conversely,
345 same-day discharge can look successful on bed utilization while shifting substantial burden to
346 outpatient teams. Both perspectives are necessary.

347 The literature reviewed here has limitations. Many studies are single-center observational cohorts,
348 pathway definitions vary, and historical controls are vulnerable to treatment-era bias. Robotic
349 expertise often increases over the same period in which enhanced recovery is introduced, making it
350 difficult to isolate the effect of the pathway. Discharge culture differs substantially between countries,
351 so a reduction from five to three days in one system may not translate to a system where day-zero
352 discharge is already routine. Randomized evidence is still limited outside selected domains, and long-
353 term oncological associations remain especially prone to confounding. The review itself is narrative
354 rather than a new quantitative meta-analysis, and it intentionally restricts references to 2020-2025,
355 meaning that foundational earlier work is represented only through contemporary syntheses.

356 Future research should use procedure-specific core outcome sets and clearly describe baseline
357 standard care. Trials should test which elements add value after modern robotic surgery rather than
358 repeatedly comparing complete bundles with outdated conventional pathways. Adaptive pathways
359 may be more useful than fixed protocols: a low-risk prostatectomy patient may need rapid discharge
360 and digital follow-up, whereas a frail cystectomy patient may need intensified nutrition, mobility
361 support, and staged discharge planning. Artificially forcing both patients through the same timetable

362 would contradict the purpose of enhanced recovery. The next generation of pathways should therefore
363 combine standardization of high-value care with personalization of intensity, monitoring, and
364 discharge timing.

365 A learning pathway also needs data infrastructure. Programs should prospectively record
366 eligibility, reasons for deviation, compliance with core elements, discharge failure, telephone contacts,
367 emergency attendance, readmission, complications, and recovery. Reviewing only mean length of stay
368 can create perverse incentives because a program may appear successful while generating avoidable
369 post-discharge contacts or caregiver burden. Stratified audit can show whether outcomes differ by
370 frailty, comorbidity, procedure complexity, distance, or social support. Such information helps teams
371 distinguish justified deviation from inconsistent practice. Review should convert these data into
372 changes in education, anesthesia orders, ward routines, discharge criteria, and follow-up. Enhanced
373 recovery then becomes a learning health-care system: standardization reduces unwarranted variation,
374 while continuous measurement identifies where personalization is necessary. This is more durable
375 than launching a protocol once and assuming benefit will remain stable as practice changes.

376 **8. Conclusion**

377 Enhanced recovery after robot-assisted urological surgery is best understood as a coordinated
378 clinical system that converts the technical advantages of minimally invasive surgery into reliable
379 functional recovery. Evidence from 2020-2025 supports shorter hospitalization and faster recovery
380 milestones across radical prostatectomy, radical cystectomy, and partial nephrectomy, with no
381 consistent signal of increased major complications or readmission when patients are appropriately
382 selected and supported. The magnitude of benefit varies by procedure and by the quality of baseline
383 care. Cystectomy continues to offer the greatest opportunity for absolute improvement, while mature
384 prostatectomy programs increasingly use enhanced pathways to standardize day-zero or day-one
385 discharge and protect patient-reported recovery rather than simply reduce bed-days. Renal surgery
386 shows encouraging results but needs stronger prospective evidence.

387 The most defensible pathway is therefore neither a universal checklist nor a discharge target. It is a
388 procedure-specific sequence of education, optimization, anesthetic and fluid stewardship, multimodal
389 analgesia, early nutrition and mobilization, rational device use, objective discharge criteria, and
390 reliable post-discharge access. High adherence matters, but adherence must be interpreted alongside
391 surgical technique, institutional experience, patient risk, and social context. Future studies should

judge success by safe recovery at home, physical well-being, low treatment burden, and consistent delivery of evidence-based care.

References

1. Long X, Du X, Wang Y, et al. Evidence-based practice and future development of enhanced recovery after surgery (ERAS) in urology: a multidimensional assessment based on the GRADE system. *J Robot Surg*. 2025;19(1):358. doi:10.1007/s11701-025-02506-y.
2. Williams SB, Cumberbatch MGK, Kamat AM, et al. Reporting Radical Cystectomy Outcomes Following Implementation of Enhanced Recovery After Surgery Protocols: A Systematic Review and Individual Patient Data Meta-analysis. *Eur Urol*. 2020;78(5):719-730. doi:10.1016/j.eururo.2020.06.039.
3. Zhao Y, Zhang S, Liu B, Li J, Hong H. Clinical efficacy of enhanced recovery after surgery (ERAS) program in patients undergoing radical prostatectomy: a systematic review and meta-analysis. *World J Surg Oncol*. 2020;18:131. doi:10.1186/s12957-020-01897-6.
4. Vangheluwe L, Legeay M, Surlemont L, Dupuis H, Defortescu G, Cornu JN, Pfister C. Clinical impact of an enhanced recovery protocol implementation for nephrectomy and radical prostatectomy. *Fr J Urol*. 2024;34(9):102674. doi:10.1016/j.fjurol.2024.102674.
5. Kitamura K, Miyoshi Y, Ieda T, China T, Shimizu F, Horie S, Muto S. Impact of the Enhanced Recovery After Surgery Protocol on the Perioperative Outcomes of Robot-Assisted Radical Cystectomy. *J Clin Med*. 2025;14(9):3082. doi:10.3390/jcm14093082.
6. Zhang D, Sun K, Wang T, Wu G, Wang J, Cui Y, Wu J. Systematic Review and Meta-Analysis of the Efficacy and Safety of Enhanced Recovery After Surgery vs. Conventional Recovery After Surgery on Perioperative Outcomes of Radical Cystectomy. *Front Oncol*. 2020;10:541390. doi:10.3389/fonc.2020.541390.
7. Ploussard G, Dumonceau O, Thomas L, et al. Multi-Institutional Assessment of Routine Same Day Discharge Surgery for Robot-Assisted Radical Prostatectomy. *J Urol*. 2020;204(5):956-961. doi:10.1097/JU.0000000000001129.
8. Rahota RG, Salin A, Gautier JR, et al. Same Day Discharge versus Inpatient Surgery for Robot-Assisted Radical Prostatectomy: A Comparative Study. *J Clin Med*. 2021;10(4):661. doi:10.3390/jcm10040661.

- 421 9. Dominique I, Palamara C, Seizilles de Mazancourt E, et al. Enhanced Recovery after Robot-
422 Assisted Partial Nephrectomy for Cancer: Is it Better for Patients to Have a Quick Discharge? *Urol*
423 *Int.* 2021;105(5-6):499-506. doi:10.1159/000505757.
- 424 10. Schiavina R, Droghetti M, Bianchi L, et al. The robotic approach improves the outcomes of ERAS
425 protocol after radical cystectomy: A prospective case-control analysis. *Urol Oncol.*
426 2021;39(12):833.e1-833.e8. doi:10.1016/j.urolonc.2021.04.015.
- 427 11. Pang Q, Duan L, Jiang Y, Liu H. Oncologic and long-term outcomes of enhanced recovery after
428 surgery in cancer surgeries - a systematic review. *World J Surg Oncol.* 2021;19:191.
429 doi:10.1186/s12957-021-02306-2.
- 430 12. Tanneru K, Jazayeri SB, Kumar J, et al. Intracorporeal versus extracorporeal urinary diversion
431 following robot-assisted radical cystectomy: a meta-analysis, cumulative analysis, and systematic
432 review. *J Robot Surg.* 2021;15(3):321-333. doi:10.1007/s11701-020-01174-4.
- 433 13. Millan B, Cassim R, Uy M, Bay B, Shayegan B. First Canadian experience with same-day
434 discharge after robot-assisted radical prostatectomy. *Can Urol Assoc J.* 2023;17(2):39-43.
435 doi:10.5489/cuaj.7914.
- 436 14. Mulholland C, Soliman C, Furrer MA, et al. Same day discharge for robot-assisted radical
437 prostatectomy: a prospective cohort study documenting an Australian approach. *ANZ J Surg.*
438 2023;93(3):669-674. doi:10.1111/ans.18198.
- 439 15. Wood A, Jivanji D, Kaplan-Marans E, et al. Same-Day Discharge After Robot-Assisted Partial
440 Nephrectomy: Is It Worth It? *J Endourol.* 2023;37(3):297-303. doi:10.1089/end.2022.0510.
- 441 16. Nakamura M, Tsuru I, Izumi T, et al. Advantages of enhanced recovery after surgery program in
442 robot-assisted radical cystectomy. *Sci Rep.* 2023;13(1):16237. doi:10.1038/s41598-023-43489-w.
- 443 17. Arslan-Carlon V, Tan KS, Dalbagni G, et al. Goal-directed versus Standard Fluid Therapy to
444 Decrease Ileus after Open Radical Cystectomy: A Prospective Randomized Controlled Trial.
445 *Anesthesiology.* 2020;133(2):293-303. doi:10.1097/ALN.0000000000003367.
- 446 18. Feenstra ML, Jansen S, Eshuis WJ, van Berge Henegouwen MI, Hollmann MW, Hermanides J.
447 Opioid-free anesthesia: A systematic review and meta-analysis. *J Clin Anesth.* 2023;90:111215.
448 doi:10.1016/j.jclinane.2023.111215.
- 449 19. Ali SN, Khanmammadova N, Myklak K, et al. Feasibility and Outcomes of Same-Day Discharge
450 after Multiport Robot-Assisted Radical Prostatectomy. *J Endourol.* 2024;38(12):1346-1352.
451 doi:10.1089/end.2024.0497.

- 452 20. Touzani A, D'Agate D, Kesch C, et al. One-year outcomes of same-day-discharge robot-assisted
453 radical prostatectomy. *BJU Int.* 2024;134(3):380-382. doi:10.1111/bju.16391.
- 454 21. Ma R, Sheybaee Moghaddam F, Ghoreifi A, et al. The effect of enhanced recovery after surgery
455 on oncologic outcome following radical cystectomy for urothelial bladder carcinoma. *Surg Oncol.*
456 2024;54:102061. doi:10.1016/j.suronc.2024.102061.
- 457 22. Mastroianni R, Tuderti G, Ferriero M, et al. Robot-assisted Radical Cystectomy with Totally
458 Intracorporeal Urinary Diversion Versus Open Radical Cystectomy: 3-Year Outcomes from a
459 Randomised Controlled Trial. *Eur Urol.* 2024;85(5):422-430. doi:10.1016/j.eururo.2024.01.018.
- 460 23. Albisinni S, Orecchia L, Mjaess G, et al. Enhanced Recovery After Surgery for patients
461 undergoing radical cystectomy: Surgeons' perspectives and recommendations ten years after its
462 implementation. *Eur J Surg Oncol.* 2025;51(3):109543. doi:10.1016/j.ejso.2024.109543.
- 463 24. Yang R, Rac G, Felice MD, et al. Robotic versus open radical cystectomy for bladder cancer:
464 evaluation of complications, survival, and opioid prescribing patterns. *J Robot Surg.*
465 2024;18(1):10. doi:10.1007/s11701-023-01749-x.
- 466 25. Petersen E, Cavanaugh D, Psutka SP. Current developments in prehabilitation in urologic
467 oncology. *Curr Opin Urol.* 2024;34(6):477-483. doi:10.1097/MOU.0000000000001224.
- 468 26. Dagnino F, Labban M, Berk B, et al. Trends and Safety of Same-day Discharge for Robot-assisted
469 Laparoscopic Prostatectomy: A Comparison Between the Pre-pandemic and Pandemic Periods
470 From the National Cancer Database. *Urology.* 2025;196:165-173.
471 doi:10.1016/j.urology.2024.10.049.
- 472 27. Najdawi F, Alcantar J, Lee DI, Shahait M, Dobbs RW. Same Day Discharge After Robotic
473 Radical Prostatectomy. *Curr Urol Rep.* 2025;26(1):27. doi:10.1007/s11934-025-01254-8.
- 474 28. Nakamura M, Muraki Y, Yamada Y, et al. Impact of Enhanced Recovery After Surgery Protocol
475 on Perioperative Quality of Life in Robot-Assisted Radical Prostatectomy: A Single-Center
476 Prospective Cohort Study. *Int J Urol.* 2025;32(11):1561-1568. doi:10.1111/iju.70177.
- 477 29. Uhrbrand CG, Obad DS, Jensen BT, Jensen JB, Friesgaard KD, Nikolajsen L. Effect of
478 intraoperative methadone in robot-assisted cystectomy on postoperative opioid requirements: A
479 randomized clinical trial. *Acta Anaesthesiol Scand.* 2025;69(1):e14545. doi:10.1111/aas.14545.
- 480 30. Pierquet G, Prévost E, Lopez L, et al. Enhanced recovery after surgery protocol does not reduce
481 the length of postoperative hospitalization after robot-assisted radical prostatectomy. *Outcomes*

482 from the first randomized controlled trial: the (PROSTA-RAAC) study. World J Urol.
483 2025;43(1):699. doi:10.1007/s00345-025-06078-2.

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