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ORIGINAL RESEARCH

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Risk factors for delayed discharge following early discharged robot-assisted laparoscopic radical prostatectomy

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Abstract

Background: Prostate cancer is one of the most common malignancies among men worldwide, and its incidence in China has been increasing rapidly. Robot-assisted laparoscopic radical prostatectomy (RARP) has become the standard surgical approach for localized prostate cancer due to its high precision and minimally invasive advantages. With the growing implementation of enhanced recovery after surgery (ERAS) protocols, early discharged surgical models have been introduced in urology to shorten hospital stays and improve patient satisfaction. However, some patients experience delayed discharge, limiting the wider adoption of early discharged RARP. This study aimed to identify the factors associated with delayed discharge in patients undergoing early discharged RARP. **Methods**: A retrospective analysis was conducted on 57 patients with localized prostate cancer who underwent RARP performed by a single surgeon between January 2023 and October 2024. Patients were divided into two groups according to whether they were discharged as scheduled (early discharged group) or had delayed discharge. Perioperative and clinical data were analyzed to determine the factors associated with delayed discharge. **Results**: Of the 57 patients, 35 (61.4%) were discharged as scheduled, and 22 (38.6%) experienced delayed discharges. Extended postoperative fasting time, delayed drain removal, and surgeries ending after 20:00 were significant predictors of delayed discharge ($p < 0.05$). Other factors, such as operative time, intraoperative blood loss, surgical approach, postoperative pain score, postoperative inflammatory markers, and pathological findings showed no significant association ($p > 0.05$). **Conclusions**: Prolonged fasting, delayed drain removal, and late surgical completion are key factors associated with delayed discharge after early discharged RARP. Optimizing perioperative management—including early feeding, timely drain removal, and proper scheduling—can enhance recovery and promote the safe implementation of early discharged RARP.

Keywords

Prostate cancer; Robot-assisted surgery; Early discharged surgery; Delayed discharge; Enhanced recovery after surgery

1. Introduction

Prostate cancer is one of the most prevalent malignancies among men worldwide, and its incidence in China has risen rapidly in recent years [1, 2]. Radical prostatectomy remains a cornerstone treatment for localized prostate cancer. Robot-assisted laparoscopic radical prostatectomy (RARP), characterized by superior visualization, precision, and functional preservation, has become the standard surgical technique globally [3–5]. In parallel, the concept of enhanced recovery after surgery (ERAS) has revolutionized perioperative management, and its integration into early discharged surgery has demonstrated benefits, such as reduced hospital stays, lower medical costs, and improved patient satisfaction [6–9]. However, not all patients can be discharged as planned, and delayed discharge remains an obstacle to the widespread application of the early discharged model [10–12]. This study retrospectively analyzed the clinical data of patients undergoing early discharged RARP performed by a single surgeon to identify factors associated with delayed discharge and to provide evidence for optimizing perioperative management.

2. Materials and methods

2.1 Patient and general information

This retrospective study included 57 patients with clinically localized prostate cancer (T1–T2c) who underwent RARP performed by a single surgeon between January 2023 and Oc-

tober 2024. Patients were divided into two groups according to discharge status: early discharged group and delayed discharge group. In this study, an early discharged procedure was defined as discharge within 48 hours after surgery. Baseline parameters, such as age, body mass index (BMI), preoperative prostate-specific antigen (PSA), Gleason score, tumor node metastasis (TNM) stage, and prostate volume were compared, as shown in Table 1. Inclusion criteria were confirmed histological diagnosis of prostate cancer, complete clinical data, no prior radiotherapy, chemotherapy, or hormonal therapy. Exclusion criteria included neurogenic bladder, hepatic or renal dysfunction, coagulation disorders, and age below 18 years. Details of recruitment are given in Fig. 1. The study was approved by the institutional ethics committee in accordance with the Declaration of Helsinki.

2.2 Interventions

All patients underwent standardized preoperative evaluation, including laboratory tests, imaging, and anesthetic assessment. RARP was performed using the da Vinci Xi robotic system via either transperitoneal or extraperitoneal approaches. ERAS protocol components include preoperative nutrition, avoidance of preoperative fasting and carbohydrate loading, no or selective bowel preparation, and early mobilization. Intraoperative management includes hypothermia prevention (warm irrigation fluid, forced-air warming), restrictive fluid management, and multimodal analgesia. Postoperative management followed ERAS principles, emphasizing early ambulation, controlled analgesia, early oral intake, and prompt removal of drains when appropriate. Discharge criteria: (1) The patient's vital signs are stable, with the ability to ambulate independently; (2) No significant discomfort is reported after consuming a semi-liquid diet; (3) The urinary catheter drainage is unobstructed, with no gross hematuria observed; (4) Postoperative pain is effectively controlled, with no signs of incision infection, fever, nausea, vomiting, or other postoperative complications; (5) Discharge is arranged with a family member to provide post-discharge care.

2.3 Statistical analysis methods

Data were analyzed using SPSS 25.0 (IBM Corporation, Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation or median (range) and compared using *t*-tests or Mann-Whitney U tests as appropriate. Categorical variables were expressed as numbers and percentages, with comparisons made by chi-square or Fisher's exact tests. Statistical significance was defined as $p < 0.05$.

3. Results

3.1 Surgical outcomes

All 57 patients successfully underwent robot-assisted laparoscopic radical prostatectomy (RARP) without conversion to open surgery, intraoperative blood transfusion, or any severe intraoperative or postoperative complications. Among them, 35 patients (61.4%) were discharged according to the early discharged protocol, while 22 patients (38.6%) experienced delayed discharge.

3.2 Comparison of perioperative parameters

There were no statistically significant differences between the early discharged group and the delayed discharge group regarding operative time, intraoperative blood loss, postoperative pain score (using the Numerical Rating Scale at 6 hours after surgery), postoperative white blood cell count (WBC), postoperative C-reactive protein (CRP) levels, or surgical approach (transperitoneal *vs.* extraperitoneal) (all $p > 0.05$), as shown in Table 2.

However, several perioperative parameters showed significant differences between the two groups. The mean postoperative fasting time was markedly shorter in the early discharged group (11.49 ± 8.28 h) compared with the delayed discharge

TABLE 1. Baseline clinical characteristics of patients in the early discharged and delayed discharge groups.

Variable	Early discharged group (n = 35)	Delayed discharge group (n = 22)	t/χ^2 value	*p* value
Age (yr)	66.91 ± 8.00	65.77 ± 7.84	0.53	0.60
BMI (kg/m^2)	24.12 ± 2.90	23.87 ± 2.28	0.44	0.66
Prostate volume (mL)	30.38 ± 16.82	33.49 ± 12.69	0.75	0.46
PSA (μg/L)	9.96 ± 5.76	13.17 ± 12.38	1.32	0.19
Gleason score, n (%)				
≤6	13 (37.14%)	14 (63.64%)	3.80	0.05
3 + 4 = 7	14 (40.00%)	5 (22.72%)		
4 + 3 = 7	8 (22.86%)	3 (13.64%)		
8–10	0 (0.00%)	0 (0.00%)		
Clinical TNM stage, n (%)				
cT1N0M0	17 (48.57%)	6 (27.27%)	2.54	0.11
cT2N0M0	18 (51.43%)	16 (72.73%)		

BMI: Body Mass Index; PSA: Prostate-Specific Antigen; TNM: Tumor Node Metastasis.

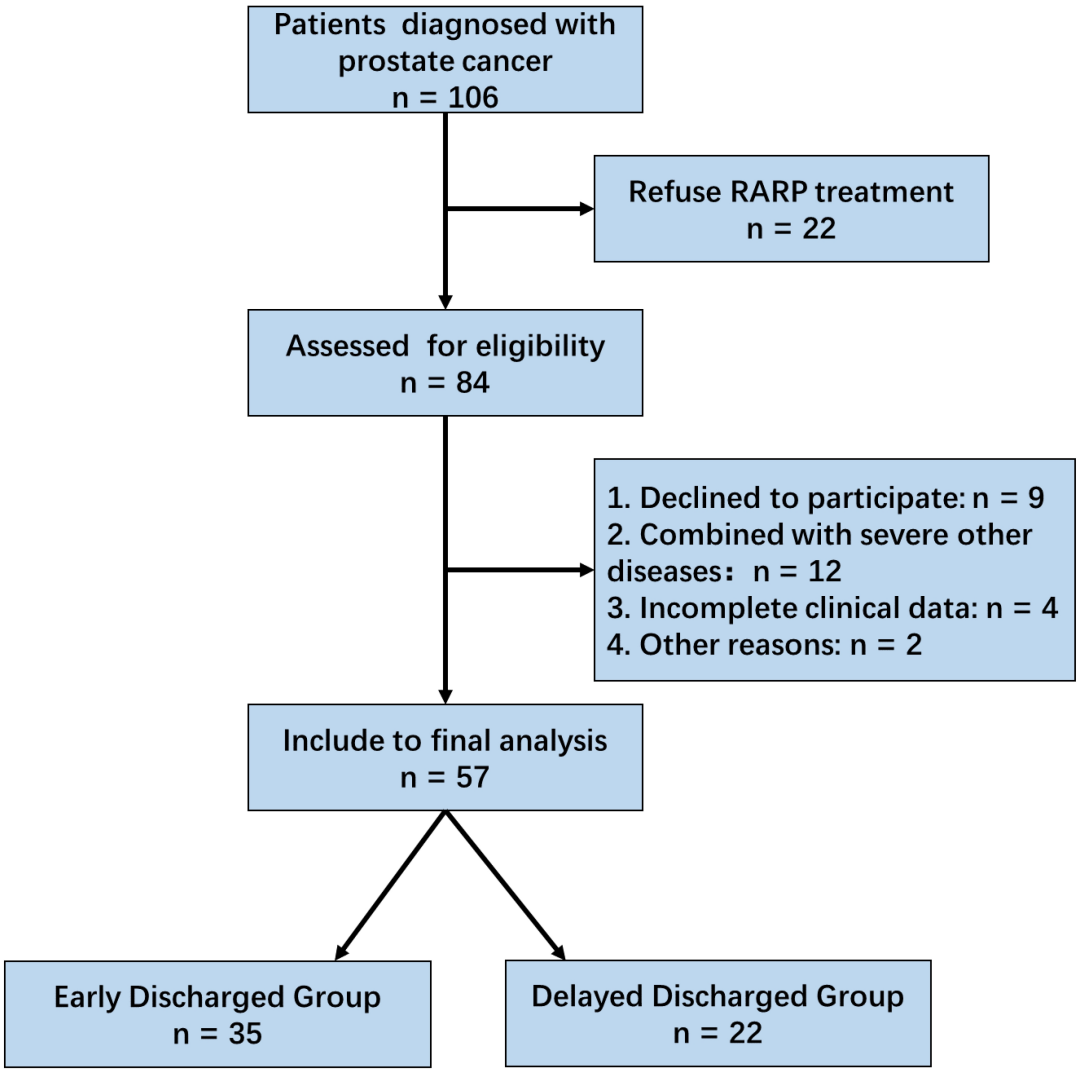

FIGURE 1. Flow chart for study participant recruitment. RARP: Robot-assisted laparoscopic radical prostatectomy.

TABLE 2. Comparison of perioperative parameters between the early discharged and delayed discharge groups.

Variable	Early discharged group (n = 35)	Delayed discharge group (n = 22)	t/χ^2 value	p value
Operative time (min)	139.90 ± 30.26	150.40 ± 39.94	1.13	0.26
Intraoperative blood loss (mL)	68.86 ± 41.57	58.18 ± 44.15	0.92	0.36
Surgical approach, n (%)				
Extraperitoneal single-port	26 (74.29%)	11 (50.00%)	2.92	0.09
Transperitoneal multi-port	9 (25.71%)	11 (50.00%)		
Postoperative WBC ($\times 10^9$/L)	8.76 ± 1.81	9.56 ± 2.69	1.34	0.19
Postoperative pain score	1.07 ± 0.28	0.95 ± 0.21	1.86	0.07
Postoperative CRP (mg/L)	20.28 ± 17.00	23.98 ± 23.66	0.66	0.51
Postoperative fasting time (h)	11.49 ± 8.28	26.05 ± 23.84	3.33	0.0016
Time to drain removal (d)	1.83 ± 1.27	3.32 ± 2.42	3.05	0.0036
End of operation time, n (%)				
Before 20:00	30 (85.71%)	13 (59.09%)	5.17	0.023
After 20:00	5 (14.29%)	9 (40.91%)		

WBC: white blood cell count; CRP: C-reactive protein.

group (26.05 ± 23.84 h) (t = 3.3323, $p < 0.05$). Similarly, the mean time to drain removal was significantly earlier in the early discharged group (1.83 ± 1.27 days) than in the delayed discharge group (3.32 ± 2.42 days) (t = 3.046, $p < 0.05$), as shown in Table 2.

3.3 Timing of surgery

The timing of surgery completion also had a notable impact on discharge outcomes. In the early discharged group, 30 patients (85.7%) completed surgery before 20:00, while only 5 (14.3%) finished after 20:00. In contrast, in the delayed discharge group, 13 patients (59.1%) completed surgery before 20:00 and 9 (40.9%) after 20:00. This difference was statistically significant (t = 5.168, $p < 0.05$), as shown in Table 2.

3.4 Pathological outcomes

No significant differences were observed between the two groups regarding positive surgical margin rates, postoperative Gleason scores, or pathological TNM stages (all $p > 0.05$), as shown in Table 3. These findings indicate that both groups achieved comparable oncological outcomes, suggesting that delayed discharge was not related to tumor characteristics or surgical radicality.

4. Discussion

With the continuous integration of minimally invasive surgery and the ERAS concept, the application of the early discharged model in RARP has become an important trend in prostate cancer surgery [13, 14]. This study retrospectively analyzed factors associated with delayed discharge in early discharged RARP to identify potential barriers to successful implementation. Among the 57 patients undergoing RARP under an early discharged protocol, 22 (38.6%) experienced delayed discharge. This proportion underscores the importance of identifying and addressing related factors. Clancy *et al.* [15] reported a 29% delayed discharge rate in 28 RARPs patients, consistent with our findings, reflecting similar perioperative care patterns in Western cohorts. George *et al.* [16] documented a lower rate (6.2%) in a cohort (n = 180) with full ERAS implementation. This finding is likely reflective of our restrictive discharge criteria, further emphasizing the clinical value of a protocol-driven management approach.

The findings demonstrated that prolonged postoperative fasting, delayed drain removal, and late completion of surgery (after 20:00) were significant factors associated with delayed discharge. In contrast, variables such as operative time, intraoperative blood loss, surgical approach, postoperative inflammatory markers, and pathological features were not significantly related to discharge timing. These observations suggest that the success of early discharged RARP relies more on perioperative management and workflow optimization than on surgical complexity itself.

Prolonged postoperative fasting emerged as one of the most influential contributors to delayed discharge. Within the ERAS framework, early postoperative oral intake is crucial for reducing surgical stress, promoting bowel function recovery, and shortening hospitalization [17–19]. In this study, patients in the delayed discharge group had significantly longer fasting durations, often reflecting delayed gastrointestinal recovery, such as postoperative nausea, vomiting, or ileus. Therefore, optimizing perioperative anesthesia management (for example, minimizing opioid use and employing prophylactic antiemetic strategies) and strengthening postoperative nursing care to safely encourage early oral intake may be key to improving the success rate of early discharged RARP. We recommend that clear liquid intake may be initiated 6 hours after surgery if the patient has no nausea, no vomiting, and positive bowel sounds; progression to a semi-liquid diet should be completed within 12 hours postoperatively.

Similarly, delayed drain removal was another factor significantly associated with prolonged hospitalization. Retained drainage tubes restrict early ambulation, increase discomfort and infection risk, and are often perceived as a sign that patients have not yet met discharge criteria [20–22]. In this study, patients in the delayed discharge group had later drain removal times than those in the early discharged group. This finding calls for a reevaluation of existing drain management strategies. When drainage is minimal and the fluid is clear, early

TABLE 3. Pathological characteristics between the early discharged and delayed discharge groups.

Variable	Early discharged (n = 35)	Delayed discharge group (n = 22)	t/χ^2 value	p value
Positive surgical margin, n (%)	15 (42.86%)	7 (31.82%)	0.69	0.40
Gleason score, n (%)				
≤6	3 (8.57%)	5 (22.73%)	2.24	0.13
3 + 4 = 7	16 (45.71%)	13 (59.09%)		
4 + 3 = 7	11 (31.43%)	2 (9.09%)		
8–10	5 (14.29%)	2 (9.09%)		
Pathological TNM stage, n (%)				
pT1N0M0	1 (2.86%)	4 (18.18%)	0.34	0.56
pT2N0M0	31 (88.57%)	17 (77.27%)		
pT3N0M0	3 (8.57%)	1 (4.55%)		

TNM: Tumor Node Metastasis.

drain removal (within 24 hours) could be considered, provided the surgeon is confident in achieving meticulous hemostasis and watertight anastomosis. A standardized, quantifiable protocol for drain management would also help reduce inter-operator variability and ensure consistent clinical decision-making.

Furthermore, the timing of surgery completion significantly affected discharge outcomes. Patients whose surgeries ended after 20:00 were at a much higher risk of delayed discharge. Late surgeries limit the time available for postoperative observation, early ambulation, and dietary progression, which may postpone crucial discharge assessments, such as pain control and complication screening, to the next day. Therefore, efficient operating room scheduling and prioritization of early discharged patients during daytime hours are vital to ensuring the smooth operation of the early discharged model.

Notably, no significant differences were observed in operative duration, blood loss, inflammatory markers, or oncological outcomes between the two groups. These findings indicate that, under the care of an experienced surgeon, RARP can reach a high degree of technical maturity and consistency. Consequently, delays in discharge appear to stem mainly from modifiable management factors rather than surgical complexity itself. This reinforces the notion that successful early discharged surgery depends primarily on perioperative planning and multidisciplinary coordination.

China has a large patient population coupled with limited healthcare resources. Against this backdrop, facilitating the early and appropriate discharge of patients has emerged as a pivotal strategy to curtail unnecessary healthcare expenditures and optimize the utilization of limited healthcare resources, particularly by reducing the opportunity cost of bed occupancy and minimizing avoidable inpatient service consumption.

Nevertheless, this study has certain limitations. It was a single-center retrospective analysis with a relatively small sample size and operation done by a single surgeon, which limits generalizability. Though we enrolled consecutive cases, 27 eligible patients were excluded, which may introduce bias. Moreover, unmeasured factors, such as psychological readiness for early discharge and family support, may also influence discharge decisions. Intraoperative intra-abdominal pressure (IAP) is also a critical physiological parameter during robotic surgery, as it exerts significant impacts on hemodynamics, renal perfusion, postoperative pain, and bowel recovery [23, 24]. Compared with high-pressure surgery, low-pressure surgery offers notable clinical advantages, including a reduced incidence of postoperative complications and a shortened hospital stay [25, 26]. Shao *et al.* [27] reported that low IAP during RARP could decrease the incidence of postoperative ileus, without significant differences in hematoma, positive margin rate, urinary retention, operative time, or intraoperative blood loss. However, in the present study, a consistent IAP of 15 mmHg was routinely maintained intraoperatively, while specific IAP-related data, including mean pneumoperitoneum pressure, duration of elevated IAP, and IAP variability, were not collected. These factors will be incorporated into our subsequent research to address this gap. More, this retrospective study only demonstrates associations between the identified factors and delayed discharge; causal relationships cannot be established. For instance, prolonged fasting may not be a cause of delayed discharge, but rather a consequence of extended hospital stays due to other clinical factors. And, we do not collect patient preference scores or family support metrics, limiting analysis of their independent impact on discharge timing. Post-discharge outcomes and cost are also uncollected, limiting assess of long-term effects and cost analysis. Future large-scale, multicenter prospective studies are warranted to validate these findings and to establish risk-stratified protocols that can further optimize early discharged RARP management.

5. Conclusions

Delayed discharge after early discharged RARP is primarily associated with prolonged postoperative fasting, delayed drain removal, and late surgery completion. Enhanced perioperative management focusing on early feeding, timely drain removal, and efficient surgical scheduling can improve the success rate of early discharged RARP and promote its broader clinical adoption.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

JY and GHL—designed this study and put it into practice. HW, JY and MCW—supervised the data collection, analyzed and interpreted the data. ZHW, JY and GHL—prepared the manuscript for publication and reviewed the draft. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study has obtained ethical approval from the Medical Ethics Committee of Sir Run Run Shaw Hospital (approval no. 20251261), and informed consent has been obtained from all patients.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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