

# Advances in Radical Prostatectomy: A Narrative Review

Austin Drysch, BS<sup>1,†</sup>; Kathryn E. Fink, BA<sup>1,†</sup>; Chalairat Suk-Ouichai, MD<sup>1</sup>; Mitchell M. Huang, MD<sup>1</sup>; Kent T. Perry, MD<sup>1</sup>; Hiten D. Patel, MD, MPH<sup>1,2</sup>; Ashley E. Ross, MD, PhD<sup>1</sup>

<sup>1</sup>Department of Urology, Feinberg School of Medicine, Northwestern University, Chicago, Illinois

<sup>2</sup>Surgery Service, Jesse Brown VA Medical Center, Chicago, Illinois

<sup>†</sup>These authors contributed equally to this work.

## Abstract

**Background:** Radical prostatectomy (RP) is the mainstay surgical treatment for men with localized prostate cancer. The use of robot-assisted RP (RARP) has specifically allowed for the development of novel techniques to improve postoperative quality of life for patients.

**Methods:** A narrative review was conducted to characterize the current state of the literature and advances for RP, with a specific focus on RARP.

**Results:** Because of improvements in perioperative outcomes, with no detriment to oncologic outcomes, RARP is currently the primary surgical intervention for prostate cancer. Several surgical techniques have been developed to reduce postoperative incontinence and optimize recovery of erectile function, including pelvic fascia-sparing and nerve-sparing surgery. Coinciding with the rise in use of RARP is a push to decrease the burden of perioperative management, such as reducing hospital length of stay, eliminating postoperative laboratory tests, minimizing opioid use, and forgoing pelvic drain placement. Modification of preoperative, intraoperative, and postoperative protocols has the potential to decrease cost without compromising clinical outcomes or patient satisfaction.

**Conclusions:** This review summarizes several advances in surgical technique and perioperative management for RP. Future study and integration of novel interventions, such as focal ablative procedures, new robotic platforms, and neoadjuvant systemic therapy, show promise for the continued improvement of surgical care for prostate cancer.

## KEYWORDS:

Prostatic neoplasms; prostatectomy; robotic surgical procedures

## Introduction

Prostate cancer (PCa) is the second-most commonly diagnosed cancer and fifth-leading cause of death among men worldwide. It is estimated that 1 in 8 men will receive a diagnosis of PCa in their lifetime and that nearly 300 000 men in the United States will receive new diagnoses of PCa in 2024.<sup>1,2</sup> Radical prostatectomy (RP) is the standard-of-care surgical treatment for patients with localized PCa and encompasses a range of techniques, including open, laparoscopic, and robot-assisted laparoscopic approaches. In the past several decades, the use of robot-assisted RP (RARP) has increased dramatically; it is estimated that more than 85% of RPs are currently performed using the Intuitive Surgical da Vinci platform.<sup>3,4</sup> This review characterizes recent advances in RP, from clinical management to surgical technique, and directions for future research.

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**Corresponding author:** Austin Drysch, BS, Department of Urology, Feinberg School of Medicine, Northwestern University, 676 N St Clair St, Ste 2300, Chicago, IL 60611 ([austin.drysch@northwestern.edu](mailto:austin.drysch@northwestern.edu))

## Surgical Technique

### SURGERY TYPE

Radical prostatectomy has been performed for more than 100 years, with successful clinical outcomes reported across all types of surgery—open RP, laparoscopic RP, and RARP. In recent decades, RARP has begun to dominate the surgical landscape for PCa, with reduced recovery periods and substantially decreased need for blood transfusions.<sup>5,6</sup> In high-volume centers, both open RP and RARP result in excellent oncologic and functional outcomes when performed by the same surgeons. Robot-assisted RP, however, is associated with modest improvement in surgical outcomes, including lower median intraoperative blood loss and transfusion rates.<sup>4</sup> Shorter length of stay (LOS) has also been consistently demonstrated with RARP.<sup>7,8</sup> In addition, a retrospective analysis demonstrated that compared with both open and laparoscopic RP, RARP was associated with improvements in immediate postoperative outcomes as well as long-term functional outcomes.<sup>9</sup> Given its superiority in surgical outcomes and similar to modest improvement in oncologic and functional outcomes, RARP has become the standard of care for PCa. As a result, we focus on novel developments in RARP that may offer further incremental improvements in surgical, oncologic, or functional outcomes that would be unattainable with an open approach.

### SINGLE-PORT SURGERY

Since 2018, the da Vinci SP system has been approved for urologic surgery, and its use has ushered in a new era of innovation for RARP surgery. The novel single-port (SP) system allows for the insertion of 3 articulating endoscopic instruments and a camera through a single laparoscopic trocar, facilitating transperitoneal, extraperitoneal, transvesical, and transperineal approaches to RARP.

Transperitoneal SP-RARP replicates the standard multiarm transperitoneal robotic approach.<sup>10,11</sup> Comparative pooled analysis between transperitoneal SP-RARP and multiport RARP at high-volume centers found that perioperative and pathologic outcomes

### ABBREVIATIONS

dHACM	dehydrated human amnion/chorion membrane
FCM	fluorescence confocal microscopy
LOS	length of stay
MRI	magnetic resonance imaging
NeuroSAFE	intraoperative neurovascular structure-adjacent frozen-section examination
NSS	nerve-sparing surgery
PCa	prostate cancer
PSM	positive surgical margin
RARP	robotic-assisted radical prostatectomy
RP	radical prostatectomy
SP	single port

were nearly equivalent between the 2 cohorts.<sup>12</sup> In a separate paired analysis, patients undergoing SP-RARP had longer operative times with less blood loss compared with patients undergoing multiport RARP, but no clinically substantial difference in postoperative pain scores was reported.<sup>13</sup>

The limitations of transperitoneal SP-RARP, including limited range of motion and lack of sweeping power, encouraged the development of alternative approaches to SP-RARP. In bypassing the peritoneal cavity, extraperitoneal SP-RARP limits peritoneal inflammation from insufflation and reduces bowel manipulation, but this technique is complicated in patients who have undergone prior procedures in the extraperitoneal space.<sup>14</sup> Comparative analysis between extraperitoneal SP-RARP and transperitoneal SP-RARP demonstrated shorter LOS and increased rate of same-day discharge in patients undergoing extraperitoneal SP-RARP, despite longer total operative time and greater estimated blood loss. No difference was noted in overall intraoperative or postoperative complication rates or positive surgical margin (PSM) rates.<sup>15</sup>

The transvesical approach to SP-RARP also provides extraperitoneal access while avoiding potential adhesions from prior abdominal surgery, unnecessary dissection and mobilization of the bladder, bowel mobilization, and Trendelenburg positioning.<sup>16</sup> Early reports from several authors have supported the safety and efficacy of this novel approach and

highlighted the early return of continence.<sup>17</sup> Most notably, a retrospective analysis from Deng et al<sup>18</sup> reported that 90% of patients recovered continence immediately after catheter removal, with 100% continence at 3 months. Pelvic lymph node dissection, especially extended lymphadenectomy, may be limited with a transvesical approach, given that the procedure is performed via the bladder neck. Consequently, this technique is not recommended in patients with a high risk of lymph node metastasis.<sup>16</sup>

Transperineal SP-RARP is modeled after the original approach to RP from 1905; however, its application is limited to select cases in centers with requisite expertise because of its technical complexity and narrow operative space.<sup>19</sup> Despite its feasibility, the steep learning curve associated with transperineal SP-RARP has limited its adoptability.<sup>20</sup>

Altogether, preliminary results across a variety of approaches demonstrate that SP-RARP is safe and feasible, offering outcomes comparable to standard multiport RARP. The learning curve and additional equipment required at this time, however, do not encourage a transition toward SP-RARP as a new standard of surgical care. Long-term, high-quality data are necessary to validate this approach's clinical equivalency or superiority.

## PELVIC FASCIA-SPARING TECHNIQUES

Recently, novel surgical techniques have been developed that focus on preserving or restoring key pelvic anatomic structures to improve patient quality of life following RP. Most relevant are Retzius-sparing and hood-sparing techniques, and both are intended to reduce the risk of short-term and long-term urinary incontinence. Galfano et al<sup>21</sup> introduced the Retzius-sparing technique in 2010, outlining a technique for RP that focused on sparing the retropubic space with the goal of preserving the natural pelvic anatomy.

Retzius-sparing RARP (RS-RARP) has been directly compared with conventional RARP across several small randomized controlled trials and prospective studies. A systematic review and meta-analysis from Barakat et al<sup>22</sup> showed a clinically significant advantage for RS-RARP in terms of urinary continence

recovery at 3 and 6 months compared with standard RARP. The authors also noted clinically significant increases in PSM rates, however, in tumors at pathologic stage pT2 or lower and pT3 or greater. No significant difference was noted in erectile function or overall postoperative complication rates.<sup>22</sup> A meta-analysis by O'Connor-Cordova et al<sup>23</sup> likewise identified greater continence recovery at 1 and 3 months following RS-RARP compared with conventional RARP. In contrast to the data from Barakat et al,<sup>22</sup> however, O'Connor-Cordova et al<sup>23</sup> found no difference in PSM rates, regardless of pathologic stage. Furthermore, no differences were noted in potency, estimated blood loss, LOS, operation time, or complication rates.<sup>23</sup> Risk of increased incidence of PSM remains a concern with the Retzius-sparing technique, albeit in the context of clear improvement in continence recovery postoperatively. Additional quality studies focusing on PSM rates in RS-RARP are necessary to validate the safety of this approach with respect to oncologic outcomes.

Wagaskar et al<sup>24</sup> subsequently developed the hood-sparing technique to address the potentially increased PSM rates found with the Retzius-sparing technique. The hood-sparing technique, which preserves the detrusor apron, endopelvic fascia, and puboprostatic ligaments in a "hood" appearance, is thought to provide additional support to the membranous urethra, external sphincter, and vesicourethral anastomosis, thereby preserving continence. In an initial series of 300 patients, continence rates at 1, 3, and 6 months following catheter removal were 83%, 91%, and 94%, respectively, with a PSM rate of 6%.<sup>24</sup> In a similar retrospective analysis, however, Shimmura et al<sup>25</sup> reported a PSM rate of 16%. The traditional anterior approach to RARP in the hood-sparing technique, which will be more familiar to surgeons, may offer an explanation for its improved PSM rates compared with the Retzius-sparing technique.<sup>24-26</sup> Validation of these findings—in particular, the superiority of the hood-sparing technique in minimizing PSM rates while preserving early continence recovery—will require quality randomized controlled trials at high-volume, experienced tertiary centers.<sup>27</sup>

**Table 1. Summary of Key Findings**

Topic	Publications	Key findings
Surgery type	Haese et al, <sup>4</sup> Coelho et al, <sup>5</sup> Coughlin et al, <sup>7</sup> Wu et al <sup>9</sup>	<ul style="list-style-type: none"> <li>• RARP is now considered the gold standard for surgical management of PCa</li> <li>• There is little evidence to suggest a significant oncologic benefit to RARP</li> <li>• RARP allows for a streamlined perioperative pathway, reduced morbidity, and potentially improved functional outcomes</li> </ul>
Single-port surgery	Dobbs et al, <sup>10</sup> Kaouk et al, <sup>11</sup> Huang et al, <sup>12</sup> Moschovas et al, <sup>13</sup> Khalil et al, <sup>14</sup> Abou Zeinab et al, <sup>15</sup> Kaouk et al, <sup>16</sup> Abou Zeinab et al, <sup>17</sup> Deng et al, <sup>18</sup> Franco et al, <sup>19</sup> Yu et al <sup>20</sup>	<ul style="list-style-type: none"> <li>• The introduction of the single-port da Vinci robot has led to the development of several approaches for single-port RARP</li> <li>• A steep learning curve and need for a large initial investment in equipment exist</li> <li>• Evidence is needed to establish clinical superiority</li> </ul>
Pelvic fascia-sparing techniques	Galfano et al <sup>21</sup> , Barakat et al, <sup>22</sup> O'Connor-Cordova et al, <sup>23</sup> Wagaskar et al, <sup>24</sup> Shimmura et al <sup>25</sup>	<ul style="list-style-type: none"> <li>• Retzius-sparing and hood-sparing techniques have been developed to reduce the risk of postoperative urinary incontinence</li> <li>• Hood-sparing RARP may reduce PSM rates (compared with Retzius-sparing RARP) while maintaining continence</li> <li>• Prospective randomized trials comparing robotic approaches are under way (ClinicalTrials.gov identifier NCT05155501)</li> </ul>
Nerve-sparing techniques	Patel et al, <sup>29</sup> Kozikowski et al, <sup>30</sup> Schlomm et al, <sup>31</sup> van der Slot et al, <sup>32</sup> Dinneen et al, <sup>33</sup> Razdan et al, <sup>34</sup> Porpiglia et al <sup>35</sup>	<ul style="list-style-type: none"> <li>• Nerve-sparing surgery during RP has been developed with the hope of mitigating postoperative erectile dysfunction</li> <li>• Preoperative MRI could be used to better plan for NSS</li> <li>• Intraoperative procedures, such as NeuroSAFE and dHACM allografts, are under continued investigation</li> </ul>
Intraoperative margin assessment	Rocco et al, <sup>40-42</sup> Baas et al, <sup>43</sup> Almeida-Magana et al <sup>44</sup>	<ul style="list-style-type: none"> <li>• FCM can be used intraoperatively to assess for PSMs and the need for subsequent secondary resection</li> <li>• Confocal laser microscopy similarly approximates final pathology analysis and can be performed using an intact tissue specimen</li> </ul>
Peritoneal flap for lymphocele prophylaxis	Lebeis et al, <sup>49</sup> May et al <sup>50</sup>	<ul style="list-style-type: none"> <li>• Peritoneal interposition flap reduces the risk of postoperative lymphocele formation</li> <li>• Due to the small number of randomized controlled trials performed, appropriate patient candidacy for peritoneal flap remains up for debate</li> </ul>
Reduction of insufflation pressure	El-Taji et al, <sup>55</sup> Abaza and Ferroni <sup>56</sup>	<ul style="list-style-type: none"> <li>• Lower insufflation pressures (<math>\leq 12</math> mm Hg) can lead to reduced LOS and reduced rates of postoperative ileus</li> </ul>
Routine lab testing	Chesnut et al, <sup>60</sup> Joseph et al, <sup>61</sup> Keating et al, <sup>62</sup> Chislett et al <sup>63</sup>	<ul style="list-style-type: none"> <li>• Routine postoperative laboratory tests, such as complete blood cell count and basic metabolic panel, largely do not affect decisions regarding transfusion for patients with RARP</li> <li>• Elimination of routine postoperative tests can lead to reduction of costs and shorter LOS</li> </ul>

*continued*

**Table 1. Summary of Key Findings, continued**

Hospital LOS/same-day discharge	Martin et al, <sup>64</sup> Abaza et al, <sup>65</sup> Ploussard et al, <sup>66</sup> Khalil et al, <sup>67</sup> Ploussard et al, <sup>68</sup> Cheng et al, <sup>69</sup> Dobbs et al, <sup>70</sup> Ye et al <sup>73</sup>	<ul style="list-style-type: none"> <li>Given the reduction in intraoperative blood loss and reduced postoperative pain, same-day discharge is feasible in many patients undergoing RARP</li> <li>Patient education both preoperatively and postoperatively is essential to patient acceptance</li> <li>Enhanced Recovery After Surgery protocols may improve bowel function and shorten LOS</li> </ul>
Opioid use, reduction, and elimination	Patel et al, <sup>76</sup> Su et al, <sup>77</sup> Shkolyar et al, <sup>78</sup> Manning et al, <sup>79</sup> Prebay et al, <sup>80</sup> Horodyski et al, <sup>81</sup> Lee et al, <sup>82</sup> Hemal <sup>83</sup>	<ul style="list-style-type: none"> <li>Opioid-free perioperative pathways are feasible and should be encouraged for patients undergoing RARP</li> </ul>
Pelvic drain placement	Ma et al, <sup>86</sup> Huang et al <sup>87</sup>	<ul style="list-style-type: none"> <li>Deferral of pelvic drain placement for patients undergoing RARP showed no significant differences in blood loss, complication rate, or LOS</li> <li>Drain placement may still be indicated for some patients</li> </ul>

Abbreviations: dHACM, dehydrated human amnion/chorion membrane; FCM, fluorescence confocal microscopy; LOS, length of stay; MRI, magnetic resonance imaging; NeuroSAFE, intraoperative neurovascular structure-adjacent frozen-section examination; NSS, nerve-sparing surgery; PCa, prostate cancer; PSM, positive surgical margin; RARP, robotic-assisted radical prostatectomy; RP, radical prostatectomy.

## NERVE-SPARING TECHNIQUES

Nerve-sparing surgery (NSS) in RP, while designed to mitigate erectile dysfunction as a postoperative adverse effect, remains challenging. Several intraoperative techniques have been developed to protect or spare neural anatomy during RP to preserve sexual function. In general, optimal functional outcomes are achieved through athermal dissection of the neurovascular bundles bilaterally, without traction, along the correct planes.<sup>28</sup> Direct comparison of nerve-sparing surgical techniques and determination of any superiority of one over another remain difficult because of the multifactorial nature of sexual potency and the challenges of postoperative assessment.

Several methodologies have been developed to balance NSS with the risk of increased PSM rates in cases in which PCa may extend beyond the capsule into the neurovascular bundles. The use of magnetic resonance imaging (MRI) before biopsy was analyzed by Patel et al<sup>29</sup> for its impact on surgical outcomes; this approach demonstrated greater use of bilateral NSS and improved cancer control in terms of biochemical recurrence compared with a non-MRI approach, adjusting for known prognostic factors.<sup>29</sup> A meta-analysis from Kozikowski et al<sup>30</sup> demonstrated

that modification of NSS based on MRI was frequent but had an uncertain impact on PSM rate. Additional prospective analysis is necessary to validate preoperative use of MRI as a prognostic factor for performing NSS.

Recent investigation has also focused on intraoperative neurovascular structure-adjacent frozen-section examination (NeuroSAFE), a novel technique, and its impact on the rate of NSS and oncologic outcomes. During the NeuroSAFE technique, intraoperative fresh-frozen section analysis of the posterolateral aspect of the prostatic margin is performed to assess whether cancer extends beyond the capsule. In the case of a positive result of pathologic testing, the ipsilateral neurovascular bundle is resected along with the rectolateral part of the Denonvilliers fascia.<sup>31</sup> A validation study performed by van der Slot et al<sup>32</sup> compared RARP with use of NeuroSAFE to standard RARP. NeuroSAFE was found to enable more frequent unilateral and bilateral NSS without negatively affecting PSM rates or biochemical recurrence.<sup>32</sup> A single-blind, multicenter randomized controlled trial of NeuroSAFE is currently under way, with an expected completion date in 2025.<sup>33</sup>

The use of dehydrated human amnion/chorion membrane (dHACM) allografts placed on the neurovascular bundles during surgery has also been investigated to mitigate the minimal nerve injury that takes place during all NSS. Cytokines, growth factors, and neurotrophic factors in dHACM are thought to accelerate the healing process, promoting earlier return of erectile function. Binary logistic regression of a matched retrospective cohort of 1400 patients who underwent full bilateral nerve-sparing RARP demonstrated that dHACM allograft placement was an independent, statistically significant predictor of potency at 1 year.<sup>34</sup> Similar efficacy in improvement of potency postoperatively has been reported in analysis of the application of chitosan membrane to the neurovascular bundle and of the application of a hyaluronic acid/carboxymethyl cellulose membrane to the prostatic bed and neurovascular plate.<sup>35,36</sup> Because earlier promising measures have failed to demonstrate efficacy, randomized controlled trials are needed.<sup>37</sup>

Finally, hydrodissection has been investigated for its potential to preserve functional outcomes without increasing PSM rates. Pedraza et al<sup>38</sup> described the saline-assisted fascial exposure technique, in which a low-pressure injection of saline solution into the periprostatic fascia achieves an atraumatic dissection of the neural hammock, and its impact on erectile function, urinary continence, and oncologic outcomes following RARP. In patients who received RARP with saline-assisted fascial exposure compared with RARP alone, better Sexual Health Inventory for Men scores were reported at 6, 13, 26, and 52 weeks after surgery. Baseline Sexual Health Inventory for Men score and use of the saline-assisted fascial exposure technique were independent predictors of erectile function recovery in this study, which requires multicenter validation to confirm efficacy.<sup>38</sup>

Sexual potency is a major quality-of-life concern among patients before RP, and addressing potency through the methods discussed here is part of the “pentafecta” of outcomes that patients will soon come to expect as functional efficacy improves.<sup>6</sup> The techniques and technologies described earlier outline a new standard approach to maximizing potency in patients following RP, from preoperative MRI to guide

surgical decision-making to the use of intraoperative NeuroSAFE or similar technology to understand exact patient pathology to the grafting of neurotrophic factor-containing biomaterials that promote postoperative healing. Modifications in addition to surgical technique, such as cliplless, lateral pedicle control and pelvic lymph node dissection in RARP with bipolar energy (vs the standard RARP technique with clips), may shorten operative time, limit clip erosion, and prevent perianastomotic stone formation. Despite concerns for increased risk of nerve injury secondary to bipolar energy use for prostatic pedicle dissection, recent studies have demonstrated similar oncologic and functional outcomes without increased risk of complications.<sup>39</sup> Individually or together, these efforts have the potential to reduce erectile dysfunction following RP, although they require further assessment in broader randomized studies.

## INTRAOPERATIVE MARGIN ASSESSMENT

Reports of increased PSM rates following nerve-sparing techniques during RP have resulted in efforts to use fluorescence confocal microscopy (FCM) to detect residual prostate tissue intraoperatively in the periprostatic environment. Compared with the previously described NeuroSAFE technique, FCM digital images can be acquired within 1 to 2 minutes per sample, permitting immediate microscopic reading by a pathologist outside the institution. In contrast, NeuroSAFE requires more than 30 minutes to perform in a fully equipped laboratory with an on-site pathologist.<sup>40</sup> A group led by Rocco et al<sup>40-42</sup> has published 3 studies on this topic, all of which found excellent agreement between FCM and subsequent hematoxylin-eosin pathology analysis. Their most recent study best elucidated the clinical application of FCM in PSM assessment, with 24 tissue specimens analyzed and subsequent secondary resection performed in 4 patients with PSMs detected intraoperatively. All 24 patients had negative surgical margins at the site adjacent to the neurovascular bundles after primary and, where applicable, secondary resection.<sup>42</sup>

Separately, Baas et al<sup>43</sup> directly compared the performance of the Histolog Scanner (SamanTree Medical), a commercially available, portable laser confocal



microscope, with the NeuroSAFE technique. Confocal laser microscopy performed by the Histolog Scanner had a calculated sensitivity of 86% and a specificity of 96% compared with the final pathologic analysis as well as substantial agreement with NeuroSAFE. In addition, the median procedure time for confocal laser microscopy was shorter than for NeuroSAFE, with statistical significance.<sup>43</sup> The primary limitation of this technique, however, is that the surgeon or pathologist must cut the tissue specimen being analyzed, which necessitates expertise in sample processing to avoid inaccurate pathology results. Almeida-Magana et al<sup>44</sup> address this limitation with the LaserSAFE technique, using the Histolog Scanner to process the entire posterolateral surface of intact RARP specimens en face. Across 31 RARP specimens, the sensitivity and specificity of LaserSAFE for diagnosis of PSM were 87.5% and 98.1%, respectively, with almost perfect agreement between LaserSAFE and final pathology analysis.<sup>44</sup> Widespread, expedient, real-time analysis of PSMs during RP appears to be on the horizon with the advent of these novel techniques.

## PERITONEAL FLAP FOR LYMPHOCELE PROPHYLAXIS

Although pelvic lymph node dissection has been shown to improve oncologic outcomes for patients with appropriate risk classification, the procedure is associated with complications. Symptomatic lymphocele occurs in roughly 2% to 10% of patients following RARP with pelvic lymph node dissection.<sup>45,46</sup> Although many lymphoceles can resolve without intervention, some require drainage and can lead to patient discomfort.<sup>47,48</sup> In 2015, Lebeis et al<sup>49</sup> proposed a novel technique in which a peritoneal interposition flap is placed between the lateral wall of the bladder and the lymphadenectomy bed to prevent the formation of lymphoceles. Lymphoceles did not develop in any of the patients who received the peritoneal flap, but lymphoceles did form in 9 of 77 (11.7%) patients who did not receive the flap.<sup>49</sup> Since the initial publication of the study by Lebeis et al,<sup>49</sup> several groups have evaluated the technique they described. In 2024, May et al<sup>50</sup> published a

systematic review based on the results of 4 randomized controlled trials. Rates of symptomatic lymphocele were 3.6% (21/580) and 7.8% (46/588) in the peritoneal interposition flap and control groups, respectively, with a pooled odds ratio of 0.43.<sup>50</sup> Although additional randomized controlled trials may be helpful to elucidate more details on technique and selection, peritoneal interposition flap placement remains a promising avenue for the reduction of lymphocele formation.

## REDUCTION OF INSUFFLATION PRESSURE

Reduction of pneumoperitoneum insufflation pressure during surgery is another area of research that has coincided with the increased prevalence of minimally invasive RP. Laparoscopic RP has traditionally been performed at a standard operating pressure of 15 mm Hg, in line with other laparoscopic procedures.<sup>51</sup> This technique has physiologic consequences, however, including reduced cardiac output, increased peak airway pressure, and metabolic acidosis.<sup>52-54</sup> In an effort to reduce the associated burden on patients, there has been interest in exploring ways to reduce intraoperative pneumoperitoneum pressure.

A meta-analysis from El-Taji et al<sup>55</sup> sought to understand the clinical impact of this technique and provide a consensus recommendation. Lower pressures during RARP ( $\leq 12$  mm Hg) resulted in a statistically reduced LOS and rate of postoperative ileus. There were no differences in operative time, estimated blood loss, PSM, or complication rates.<sup>55</sup> Furthermore, a randomized controlled trial by Abaza and Ferroni<sup>56</sup> established statistically significant reductions in immediate, maximum, shoulder, and groin pain scores in patients with ultralow insufflation pressure with RARP (6 mm Hg) compared with standard insufflation pressure (15 mm Hg). Whereas there was no statistical difference in morphine equivalents intraoperatively or postoperatively, earlier flatulence was observed in the group with ultralow pressure.<sup>56</sup> Although there is promising evidence supporting the use of lower pressures, further validation is necessary to establish a safe minimum for pneumoperitoneum insufflation pressure.

## Perioperative Management

### ROUTINE LAB TESTING

Routine postoperative tests, including complete blood cell count and basic metabolic panel, are frequently obtained following RP. Traditionally, these tests were performed to assess bleeding and the need for transfusion following open prostatectomy, but the increasing prevalence of minimally invasive surgical techniques has reduced the risk of significant bleeding and transfusion following RP to 0% to 3%.<sup>4,57-59</sup> Clinical benefit and costs to the patient and hospital for routine postoperative tests should also be considered.

Recently, several studies have scrutinized the clinical utility of perioperative labs. Chesnut et al<sup>60</sup> retrospectively analyzed a cohort of 3631 patients to determine the utility of 4-hour and 14-hour postoperative hemoglobin assessments in predicting the need for transfusion. No clinical decisions were made using information gleaned from the 4-hour assessment. In addition, only 44 patients (1.2%) received a blood transfusion, and 18 (41%) of these transfusions were based solely on laboratory test values. The financial burden of the unnecessary 4-hour test for the institution was \$37 000.<sup>60</sup> Joseph et al<sup>61</sup> performed a similar analysis with a cohort of 3405 patients and found that of the 1.7% of patients who received a transfusion, 96% had clinical symptoms of anemia that would have prompted further testing.

Keating et al<sup>62</sup> retrospectively reviewed 200 patients who underwent RARP and found that only 15 (7.5%) had laboratory test abnormalities that resulted in medical intervention, all of which were associated with prolonged inpatient stay. Most recently, Chislett et al<sup>63</sup> retrospectively analyzed a 300-patient cohort and found that eliminating routine postoperative tests did not change the course of care and led to a median LOS that was 1 day shorter than the LOS for patients undergoing these tests, representing a substantial cost benefit for patients and the health care system. Based on the literature, there is reason to question the utility of routine postoperative tests following RARP because these tests may be an artifact of open

procedures, which are associated with greater blood loss.

### HOSPITAL LOS/SAME-DAY DISCHARGE

Decreased intraoperative blood loss and reduced perioperative pain with RARP raise the question of whether an inpatient stay is actually needed. Same-day discharge following RARP was first reported by Martin et al<sup>64</sup> in 2010 in a cohort of 11 patients, all of whom were discharged without complication. Several studies have since corroborated that same-day discharge does not increase the risk of 30-day readmission compared with next-day discharge.<sup>65-67</sup>

Despite its reported safety, an overnight stay following RARP is still the standard of care at most institutions. In a countrywide retrospective analysis of all RARPs performed in France within 1 year, Ploussard et al<sup>68</sup> found that only 184 of 9651 RARPs (1.9%) involved same-day discharge.<sup>68</sup> The reduction in LOS also affects cost to patients and the hospital system. Abaza et al<sup>65</sup> approximated a reduction in charges of \$345 876 per year as a result of same-day discharge, with no increased cost resulting from emergency department visits or hospital readmissions. Cheng et al<sup>69</sup> performed a time-driven, activity-based cost analysis and found a 19% reduction in cost to patients who had same-day discharge, with similar median satisfaction survey scores. Given the large volume of RARPs performed in the United States and worldwide each year, the potential fiscal impact of implementing same-day discharge is substantial.

Patient acceptance, in addition to historical precedence, could be a barrier to same-day discharge. Dobbs et al<sup>70</sup> studied barriers to same-day discharge and found that postoperative pain, catheter discomfort, and insufficient education on pain management and catheter care were the primary factors inhibiting early discharge. Abaza et al<sup>65</sup> emphasized the importance of proper education at consultation, preoperatively, and postoperatively to facilitate smooth discharge. These findings indicate that with proper education before surgery, patient acceptance is less a barrier than has previously been suggested.

In addition, several studies have examined the use of Enhanced Recovery After Surgery protocols. These



protocols were first described by Kehlet<sup>71</sup> in 1997 and have since been adopted in numerous specialties; the protocols include a variety of surgical, anesthesia, and nursing interventions that take place preoperatively, intraoperatively, and postoperatively.<sup>72</sup> A 2020 meta-analysis of 10 studies found that the use of Enhanced Recovery After Surgery protocols following RP was associated with shorter time to first defecation, shorter time to first anal exhaust, shorter hospital LOS, and less nausea.<sup>73</sup>

## OPIOID USE, REDUCTION, AND ELIMINATION

In recent decades, opioid-related deaths have become an urgent public health issue in the United States. In 2021, 1 of every 22 deaths was attributed to unintentional opioid toxicity.<sup>74</sup> An estimated 6% to 7% of patients experience persistent opioid use after surgical procedures, which evokes the need for conservative prescribing whenever possible.<sup>75</sup> Overprescribing of opioids postoperatively is common and can lead to issues with medication disposal and diversion after the patient leaves the hospital.<sup>70</sup>

One of the earliest interventions aimed at reducing postoperative opioid use following RP was the Open, Laparoscopic, and Endoscopic Surgery Initiative in 2020. In this study, Patel et al<sup>76</sup> developed a pre-post interventional trial aimed at reducing total oral morphine equivalents following RP. In the postinterventional arm, there was a 46.4% reduction in opioid prescriptions, a 26.5% reduction in opioid use, and a 13.5% increase in opioid disposal compared with the preinterventional arm.<sup>76</sup> Additional analysis of this patient cohort demonstrated that inpatient opioid use, patient-reported pain scores, prior opioid use, and body mass index were all predictors of opioid use following discharge.<sup>77</sup>

A study by Shkolyar et al<sup>78</sup> found that patients undergoing RARP were 35% less likely to experience new, persistent opioid use than patients undergoing open RP. Manning et al<sup>79</sup> developed a multidisciplinary opioid-reduction pathway for patients undergoing RARP that used a series of educational, nursing, and nonopioid analgesic interventions. A statistically

significant decrease in intraoperative and postoperative opioid use was noted for patients who underwent the intervention, underscoring the potential for wide-scale opioid de-escalation.<sup>79</sup> These findings suggest that individualized opioid prescribing, combined with patient education on proper opioid use, may help reach a balance between undertreatment and overprescribing.

In addition to opioid reduction efforts, several studies have evaluated complete elimination of opioids in addition to opioid-reduction efforts following RP. Prebay et al<sup>80</sup> and Horodyski et al<sup>81</sup> developed opioid-free interventions to evaluate postoperative pain and found noninferior pain scores. Although opioid use will likely remain necessary for some patients, these findings suggest that it can be spared in the majority of patients. Lee et al<sup>82</sup> performed a randomized noninferiority trial to compare the efficacy of a nonopioid multimodal analgesia protocol against standard opioid protocols. No significant differences in 24-hour postoperative pain scores were observed, and the nonopioid multimodal analgesia group exhibited a quicker return to normal bowel function than did the opioid group.<sup>82</sup>

An ongoing phase 2/3 trial is investigating the use of an opioid-free pathway following RARP.<sup>83</sup> Patients randomly assigned to the experimental arm receive perioperative ketamine, ketorolac, and intravenous acetaminophen followed by postoperative ketorolac and oral acetaminophen; results are expected in 2025. Results of this trial will add power to previous findings regarding opioid-sparing RARP.

## PELVIC DRAIN PLACEMENT

Pelvic drain placement following RP is a common practice to remove lymph, blood, urine, and other fluids from the patient. Notably, patients are more likely to experience pain and infection at the site of drain placement.<sup>84</sup> Several studies have analyzed the need for pelvic drain placement after RARP. Abaza et al<sup>85</sup> retrospectively reviewed more than 4600 interventions performed by a single surgeon, 3692 of which were prostatectomies. They noted that 99.6% of the patients undergoing RP did not receive a pelvic

drain. In a 90-day follow-up, only 3 patients (0.08%) experienced urine leaks, which indicates that routine drain placement is unnecessary in the vast majority of patients. A 2023 meta-analysis of 6 studies comprising 1480 patients evaluated outcomes of RARP with drain placement vs RARP without drain placement.<sup>86</sup> No significant differences in blood loss, complication rates, or hospital LOS were observed between the 2 groups. Huang et al<sup>87</sup> specifically included opioid use following surgery as an end point and found no difference in complication rates or opioid use following surgery. Although certain circumstances may warrant drain placement, including extensive pelvic lymph node dissection or an anastomotic leak, findings suggest that drain placement can be deferred with appropriate clinical judgment in the majority of patients following RARP.<sup>84,88</sup>

## Summary and Future Directions

As treatment for PCa continues to evolve, the goal of surgical intervention remains oncologic control while preserving functional outcomes and minimizing perioperative morbidity. Robotic prostatectomy currently allows for a streamlined perioperative pathway that can omit opioid use, routine laboratory tests, and pelvic drain placement and allow for same-day discharge. Techniques that may improve functional outcomes without compromising oncologic control have been developed (ie, anterior fascial or Retzius sparing), and these methods are being validated for potential superiority in prospective randomized studies. Novel emerging robotic platforms represent the most immediate advancement in the field. Robotic surgical systems with distinct functionality may eventually prove pivotal in the development of surgical techniques previously not deemed feasible using the da Vinci platform. Also importantly, these systems may improve surgeon ergonomics and reduce operative times. Reliability and efficacy in surgical and functional outcomes have been proven with the Hugo RAS system (Medtronic), as demonstrated in a comparative study between patients who underwent RARP with the da Vinci surgical system

and patients who received RARP using the Hugo RAS system.<sup>89</sup> The Revo-i surgical robotic system (Meere Company) and the Versius surgical robot (CMR Surgical) have also shown promise in RARP, albeit in limited patient cohorts.<sup>90-93</sup>

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