Optimizing Surgical Techniques in Robot-Assisted Radical Prostatectomy

Camilo Arenas-Gallo, MD[a], Jonathan E. Shoag, MD, MS[b,c,*], Jim C. Hu, MD, MPH[d]

KEYWORDS

• Prostatectomy • Prostate cancer • Robotic surgical procedures • Prostate

KEY POINTS

- Robot-assisted radical prostatectomy (RARP) is the most common surgical treatment of localized prostate cancer, which has almost completely replaced standard laparoscopic and open radical prostatectomy in the United States.
- Surgeon experience and surgical technique are associated with better RARP outcomes.
- The benefit of new techniques and maneuvers are best assessed by randomized trials. To date, there are few such trials to guide technique.

INTRODUCTION

The initial description of radical prostatectomy to treat prostate cancer is generally attributed to Hugh Hampton Young, who published the procedure in 1905.[1] The most important subsequent technical modification was the description of the neurophysiology and anatomy of the prostate in the 1980s, by Patrick Walsh, who developed the nerve-sparing technique.[2] The rapid adoption of robot-assisted radical prostatectomy (RARP) over the past 20 years constitutes the most recent major change technical modification to this procedure.[3]

RARP has rapidly become the preferred modality for radical prostatectomy. Although the benefits of RARP versus open retropubic radical prostatectomy in experienced hands may be minimal, the robotic technique is associated with less blood loss and shorter hospital stays than open surgery.[4,5] RARP has almost completely replaced standard laparoscopic radical prostatectomy, and in 2010, it was estimated that 80% of radical prostatectomies in the United States were performed robotically.[3] More recent data estimate that RARP comprises more than 90% of all radical prostatectomies performed. This modality has now been adopted in both community and academic centers.[6]

Several anatomic descriptions and technical modifications have been proposed to improve functional outcomes after RARP. Here, the authors review critical maneuvers to preserve urinary and sexual function following RARP.[3]

Overview of the Nerve-Sparing Technique

The first nerve-sparing prostatectomy was performed in 1982 by Patrick Walsh.[2] The discovery and description of the anatomy of the neurovascular bundle (NVB) that surrounds the prostate

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[a] School of Medicine, Universidad Industrial de Santander, Cra 21 No 158-80 Casa 83, Floridablanca, Santander 681004, Colombia; [b] Department of Urology, University Hospitals Cleveland Medical Center, Case Western Reserve University School of Medicine, Case Comprehensive Cancer Center, 11100 Euclid Ave, Cleveland, OH 44106, USA; [c] Department of Urology, New York Presbyterian Hospital, Weill Cornell Medicine, 24610 Sittingbourne Drive, Bechwood, NY 44122, USA; [d] Department of Urology, New York Presbyterian Hospital, Weill Cornell Medicine, 413 East 69th Street, Starr 946, New York, NY 10021, USA
* Corresponding author.
E-mail address: Jonathan.shoag@uhhospitals.org

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defined a new era in prostatectomy, allowing the preservation of erectile function in a greater number of patients.[7] Before this, it was universally accepted that radical prostatectomy led to the absence of any erectile function. It is now recognized that even in the presence of high tumor volume or extracapsular disease, nerve sparing can often be performed to some degree.

It is now widely recognized that preoperative erectile function is the main predictor of recovery from postprostatectomy erectile function.[8] In addition, cardiovascular risk factors such as dyslipidemia, diabetes mellitus, hypertension, coronary artery disease, and smoking have also been found to be independent predictors of erectile dysfunction.[9] In addition to these factors, it is widely accepted that optimal nerve-sparing technique plays a critical role in maintaining erectile function following surgery.[10]

The nerve-sparing technique can be broadly classified as antegrade or retrograde depending on the direction of dissection. The antegrade approach advances from the prostatic base to the apex and includes ascending traction of the vessels and seminal vesicles, athermal control of the prostatic pedicle, and exposure of the lateral pelvic fascia. The NVB is exposed when entering the space between Denonvilliers fascia, lateral pelvic fascia, and the prostate. Reflection of the lateral pelvic fascia outside the prostate exposes the interfascial or intrafascial planes for dissection[11] (**Figs. 1** and **2**).

The retrograde approach begins from the prostatic apex and continues toward the base. It includes dissection of the seminal vesicles and development of the posterior plane. The prostate is then retracted away from the side of interest, and the levator fascia is opened to expose the NVB. Subsequently, the dissection between the prostate and the NVB is performed in an inter- or intrafascial approach, depending on disease burden, until the previously developed posterior plane is reached and the NVB is completely separated from the prostate.[11]

Apical dissection is a critical step in radical prostatectomy because the nerves responsible for erection and continence come in close proximity to the prostatic apex. The pudendal nerve perforates the levator ani at the apex of the prostate and sends branches to the sphincter in this position.[3] Damage to the nerves responsible for erection may be more likely to occur at this location because of its proximity to the prostatic apex.

Sometimes, in locally advanced prostate cancer more extensive excision must be performed and preservation of the NVB may be challenging. However, studies have shown that extracapsular extension of prostate cancer rarely extends histologically beyond 3 mm,[12] whereas anatomic studies have shown that the distance between the prostate capsule and the cavernous nerves (found in a bundle of the posterolateral fascial compartment) is around 5 mm.[13] Therefore, even if preoperative MRI of the prostate suggests extracapsular extension, the nerves may not have to be completely resected. If the extracapsular disease is unilateral, then preservation of the contralateral side can preserve functional outcomes.[3]

Based on the plane of dissection, a nerve-sparing technique can be classified as intrafascial or interfascial[14] (**Fig. 3**). Dissection in the intrafascial plane, located between the capsule and the

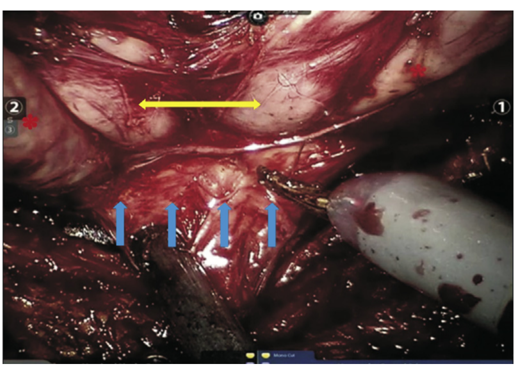

Fig. 1. Posterior prostatic dissection plane. Yellow arrow means vas deferens; blue arrows mean Denonvillier fascia; asterisk means seminal vesicles tissue. (*From* Tavukçu HH, Aytac O, Atug F. Nerve-sparing techniques and results in robot assisted radical prostatectomy. Investig Clin Urol. 2016;57(166):S172–84.)

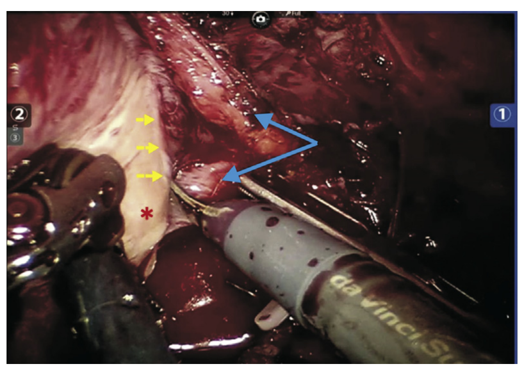

Fig. 2. Right intrafascial dissection; prostate and right neurovascular bundle (NVB). Yellow arrows mean dissection plane; blue arrow means NVB; asterisk means prostate capsule. (*From* Tavukçu HH, Aytac O, Atug F. Nerve-sparing techniques and results in robot assisted radical prostatectomy. Investig Clin Urol. 2016;57(166):S172–84.)

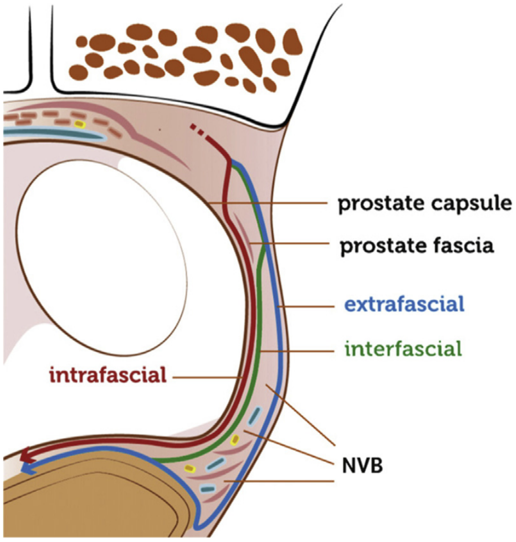

Fig. 3. The axial section of prostate and periprostatic fasciae at midprostate with 3 different dissection planes (intrafascial [*red line*], interfascial [*green line*], and extrafascial [*blue line*]). NVB, neurovascular bundle. (*From* Salonia A, Burnett AL, Graefen M, Hatzimouratidis K, Montorsi F, Mulhall JP, et al. Prevention and management of postprostatectomy sexual dysfunctions part 1: Choosing the right patient at the right time for the right surgery. Eur Urol. 2012;62(2):261–72.)

prostatic fascia, allows total preservation of the NVB. In contrast, dissection in the interfascial plane, located between the prostatic fascia and the lateral pelvic fascia, allows a greater probability of negative surgical margins at the expense of partial preservation of the NVB. The surgeon selects the appropriate plane for each patient based on the anatomy and extent of the cancer.[15] Kowalczyk and colleagues[16] described splitting the capsular vein along the NVB as a landmark for interfascial nerve sparing, as the vein is often the most medial component of the anterior medial aspect of the NVB.

Potdevin and colleagues[17] retrospectively compared 147 patients undergoing interfascial versus intrafascial athermic nerve sparing to assess the benefit of the latter's conservation of more anterolateral nerve fibers. They found potency rates at 9 months in the intrafascial group of 90.9% versus 66.7% in the interfascial group ($P<.01$). However, the improvement in functional outcome came at the tradeoff of increased rates of positive surgical margins in pT3 disease, 41.18% in intrafascial versus 22.2% in interfascial ($P<.05$). No differences were found in complication rates, continence rates at 6 months, and positive margin rates in patients with pT2 disease.

A systematic review and meta-analysis published in 2017 by Weng and colleagues[18] compared intrafascial versus interfascial nerve-sparing prostatectomy for localized prostate cancer. They included 6 trials of open, laparoscopic, and robotic prostatectomy and demonstrated that the intrafascial approach was associated with better continence rates at 6 months (risk ratio [RR] = 1.18, 95% confidence interval [CI] 1.08–1.30, $P = .0002$) and 36 months (RR = 1.13, 95% CI 1.02–1.25, $P = .02$). In addition, the intrafascial approach was associated with better potency recovery at 6 months (RR = 1.49, 95% CI 1.01–2.18, $P = .04$) and 12 months (RR = 1.40, 95% CI 1.24–1.57, $P<.00001$). However, the quality of evidence was very low for oncologic outcomes.

Neuropraxia or tension on the NVB is also thought to affect recovery of erectile function: minimizing lateral displacement of the NVB is associated with earlier and better recovery of erectile function. Kowalczyk and colleagues[16] made a retrospective study comparing sexual function outcomes for nerve sparing without countertraction versus with assistant and/or surgeon NVB countertraction. They measured the sexual function using the Expanded Prostate Cancer Index Composite (EPIC), scored from 0 to 100, with higher scores representing better outcomes, and found that nerve sparing without assistant countertraction was associated with higher 5-month sexual function (20 vs 10; $P<.001$). However, no difference in sexual function or potency was observed at 12 months dependent on this approach. There were no significant differences in positive surgical margins between techniques.

Surgeon experience has also been shown to play a role in outcomes. Alemozaffar and colleagues[19] in a retrospective study of 400 consecutive RARPs demonstrated greater surgeon experience was associated with better 5-month sexual function (parameter estimate [PE]: 5.21; 95% CI, 1.4 to 9.02) and with a trend for better 12-month sexual function (PE: 0.06; 95% CI, 0–0.12). In addition, trainee robotic console involvement during nerve sparing was associated with worse 12-month sexual function (PE: −12.58; 95% CI, −23.23 to −1.92), demonstrating a learning curve effect.

Several studies have suggested that meticulous preservation of the NVB in radical prostatectomy improves the results of postoperative continence. Possible reasons for this include the preservation of intrapelvic somatic supply to the external striated rhabdosphincter.[20] A 2015 meta-analysis of 27 cohort studies with a total of 13,749 patients demonstrated that postoperative continence was achieved faster with the nerve-sparing technique compared with non–nerve-sparing technique in the first 6 months after surgery (RR 1.20, CI 1.04–1.39; P = .02). However, there was no difference in incontinence outcomes beyond 6 months (RR 1.09, CI 0.97–1.22), regardless of whether or not a nerve-sparing procedure was performed.[21] Additional studies are needed to improve the understanding of male urinary continence and the pathophysiology of postradical prostatectomy incontinence and its relationship to nerve sparing.[20]

The Veil of Aphrodite Technique or "High Anterior Release"

The technique known as high anterior release or "the veil of Aphrodite" to preserve the NVB was described in 2006 by Menon and colleagues.[22] In this approach, the surgeon develops a plane between the prostatic capsule and the prostatic fascia at the base of the seminal vesicles. The next step is a meticulous bilateral interfascial dissection between 1 and 5 o'clock on the right side, as well as 6 and 11 o'clock on the left side. At the end of the dissection, the curtains of periprostatic tissue are suspended from the pubourethral ligament, which is also known as the "veil of Aphrodite." This approach involves resection of the periprostatic fascia on the lateral sides of the prostate to drop the fascia and prevent damage to the NVB below.[3] It is suggested that this technique may improve potency compared with conventional nerve-sparing while not compromising oncologic outcomes. The original technique was later modified by extending the anterior interfascial dissection and preserving the pubovesical ligaments and the dorsal vein plexus ("superveil technique").[23] The rationale for this technique has been questioned in a subsequent cadaveric analysis of the distribution of the periprostatic nerves, where the level of the cavernous nerves in the neurovascular bundle was examined.[24,25] This study found that most of the nerves of the NVB were located inferolateral to the prostate above the rectum; therefore, the high release of the fascia above the midline of the prostate may have little effect in preserving these important nerves.[3]

Preservation of the Urethral Smooth Muscle Preservation

The urethral sphincter is made up of 2 muscle types: the outer, horseshoe-shaped striated muscle fibers and inner elastic tissue and smooth muscle fibers that are completely circular in men and are present mainly at the proximal urethra.[26] *Schlomm and colleagues* described a full-length preservation of the urethral sphincter by identifying and dissecting the distinct striated and smooth muscle part of the sphincter inside the prostate apex until the colliculus seminalis is encountered. This technique allows preservation of the full functional-length urethra and of the anatomic fixation of the urethral sphincter complex. This approach resulted in early continence results in 406 consecutive patients compared with standard RARP: 50.1% versus 30.9% 1 week after catheter removal (P<.0001) and 96.9% versus 94.7% (P = .59) at 12 months after surgery.[27] However, others contend that the urethral sphincter smooth muscle supplies only passive continence and true active continence is mediated by the striated muscle, which is innervated by the pudendal nerve,[28] therefore, preservation of urethral smooth muscle does not have an anatomic basis for improving postoperative continence after radical prostatectomy. Nevertheless, as a general anatomic principle, most of the urethra and the surrounding muscle should be preserved.

The Suburethral Plication Stitch

Some studies have suggested that a plication stitch, also known as a Rocco stitch, which extends suburethrally at the apex of the prostate to the Denonvilliers layer below the bladder, aids in the restoration of postoperative continence. In addition to making the anastomosis technically easier, theorized benefits of the stitch include restoration of the length of the urethrosphincteric complex, avoiding its retraction, withdrawal of excessive tension in the posterior vesicourethral anastomosis, and provision of a posterior pillar to the urethral sphincter complex to facilitate its effective contraction.[29]

A meta-analysis published in 2012 concluded that factors that affect the risk for urinary incontinence after RARP include patient preoperative characteristics (age and preoperative potency), surgeon experience, surgical technique, and the methods used to collect the report data and that the reconstruction posterior muscle fascial with the Rocco stitch seems to offer a slight advantage at 1 month after surgery but not afterward.[30] A prospective, randomized trial of this approach found no benefit with rhabdosphincter reconstruction versus standard vesicourethral anastomosis in terms of early return of urinary continence after RARP.[31] Similarly, Woo and colleagues[32] in a retrospective analysis found no statistically significant difference in outcomes depending on whether the stitch was used.

Urethral suspension techniques have also been studied for improving urinary function. Canvasser and colleagues[33] explored a posterior urethral suspension technique at the time of anastomosis in a case control study of 83 patients. This suspension is made with the intention of lightly and minimally elevating the anastomosis to avoid urethral compression while limiting membranous urethra/sphincter complex descent with increases in intra-abdominal pressure. Patients with the urethral suspension required less protective incontinence products at 1 and 2 weeks after catheter removal (P<.03) and had pad-free rates of 60% compared with 36% among controls at 12 weeks after catheter removal (P = .07).[33]

Others have studied the effect of vas suspension on urinary continence. *van der Poel and colleagues*[34] conducted a randomized trial of 112 patients evaluating a vas deferens urethral support technique. They hypothesized that ventral rather than cranial support of the dorsal urethral plate is required for proper sphincter function. Accordingly, the investigators used a ventral support technique using the vas deferens and compared with standard anastomosis during RARP. Vas suspension improved early continence at 1 month (59% vs 35%, P = .02); however, men also reported loss of urine significantly more often due to urgency (ICIQ-SF question 4b) at the 1-month interval (26% vs 11%, P = .03). No significant differences in full urine continence or pad use was observed at later time points.[34]

Seminal Vesicle-Sparing Prostatectomy

Thermal injury and traction may also contribute to poor functional outcomes after prostatectomy. Anatomic studies demonstrate the proximity of neurovascular tissue to the seminal vesicles and the posterior neck of the bladder,[35] leading to the proposition that seminal vesicle preservation may be beneficial.[36] A 2017 randomized controlled trial of 140 patients assessing this hypothesis compared functional outcomes after standard nerve-sparing RARP versus enhanced nerve-sparing technique with the preservation of the seminal vesicles.[37] The study found no differences in sexual and continence functional scores, surgical margin status, or PSA biochemical recurrence between the groups and concluded that preservation of the seminal vesicles was not an effective intervention.

This conclusion was supported by anatomic studies by a group at the Royal Melbourne Hospital, which showed that the autonomic neural components of the NVB were within a reasonable distance from the ends of the seminal vesicles.[38] The parasympathetic autonomic nerves S2 to S4 join a ganglion 1 to 2 cm from the ends of the seminal vesicles, near the base of the prostate. Therefore, dissection of the seminal vesicles is unlikely to alter the autonomic function or improve functional outcomes.

Prostatic Vasculature as a Landmark

Patel and colleagues[39] described the use of vascular landmarks to aid in identification of the proper plane for nerve sparing during prostatectomy. This technique relies on identification of an artery that runs along the lateral edge of the prostate, which could correspond to a prostate or capsular artery, that can be recognized after opening the levator fascia at the base of the prostate. The prostate artery is a larger tortuous vessel seen on the medial aspect of the NVB. In contrast, the capsular arteries are smaller without tortuosity, which makes them more difficult to visualize, and are located more distally in relation to the prostatic artery. The dissection plane is identified between one of these landmark arteries and the prostate at the midprostate. Dissection then continues retrograde to the posterior plane and the base of the prostate. After controlling the prostatic pedicles at the base, the dissection is performed antegrade to the apex.[15]

Retrograde Release of the Neurovascular Bundle with Preservation of the Dorsal Venous Complex

In 2018, de Carvalho and colleagues[40] introduced a technical modification of the RARP with nerve preservation, in which the retrograde release of NVB allows the preservation of nervous and vascular structures. In this study, the functional and oncological results were described in 128 patients operated by a single surgeon. This technique involves incision of the anterior peritoneum to access the space of Retzius, dissection of the overlying fatty tissue, and dissection of the anterior neck of the bladder without entering the endopelvic fascia or ligating the dorsal venous complex (DVC). Next, an incision is made in the posterior neck of the bladder, and dissection of the vas deferens and seminal vesicles is performed. The NVB is released starting at the level of the bladder neck, developing an avascular plane below the DVC, and thereafter the dissection continues laterally. Prostatectomy with complete nerve preservation is performed when the NVB is dissected medially to the prostate artery, fusing this plane with the previously developed posterior plane. So far there have been no randomized trials comparing this approach with the standard one.

Retzius-Sparing Radical Prostatectomy

Galfano and colleagues[41] in 2010 described a surgical technique for RARP known as a posterior or "Retzius-sparing." It has been suggested that this could enable earlier continence recovery compared with the traditional technique.[42] This approach is based on the idea of performing an RARP exclusively through the pouch of Douglas space, thus avoiding any interruption of the anterior anatomic structures that surround the prostate gland such as the pubovesical ligaments, puboprostatic fascia, NVBs, and the dorsal venous complex. It is thought that preserving these structures may result in better functional results.[43]

In 2014, Lim and colleagues[44] reported a similar RARP technique with the preservation of the space of Retzius. In this approach, surgery begins with an incision through the peritoneum posterior to the bladder, and the seminal vesicles are dissected as a first step. Initial reports on this technique described a high T2-positive margin rate of 12% compared with 5.3% in another robot-assisted laparoscopic prostatectomy (RALP) cohort. This high positivity rate of the T2 margin was suggested to be the resultant from a steep learning curve associated with performing this technique.

Another study published in 2018 investigated functional recovery, cancer outcomes, and postoperative complications in 120 patients after S-RARP versus RS-RARP.[45] The investigators concluded that in patients with low-risk or intermediate-risk prostate cancer, the results at a 12-month follow-up point were not significantly different on any of the measurable parameters and that the return to continence after RS-RARP was not different from conventional RARP (P = .001).[46] However, the RS-RARP approach is technically difficult, associated with a high learning curve (plateau after 200–300 cases)[47,48] and must be performed by surgeons skilled in the standard RARP technique.

A systematic review and comparative analysis of standard RARP (S-RARP) and RARP with preservation of Retzius (RS-RARP) was recently published.[49] The investigators included 8 clinical studies. The results showed a shorter operating time with the RS-RARP; however, this was only a 14.7-minute time difference (weighted mean difference 14.7 min, P = .03). No significant differences were found in terms of estimated blood loss or postoperative complications; however, the positive surgical margin rate was lower for the S-RARP group (rate 15.2% vs 24%; odds ratio 1.71, P = .01), which may be influenced by the RS-RARP learning curve. This is an important issue because the investigators suggest that higher rates of positive margins could translate into greater need for adjuvant or salvage radiation therapy, with the potential for associated morbidity. The cumulative analysis did show a statistically significant advantage for RS-RARP compared with S-RARP in terms of continence recovery at 3, 6, and 12 months (P = .004). A recently published comparative analysis of a single surgeon series of 70 RS-RARP versus 70 S-RARP showed no differences in sexual function but improved overall continence rates at total follow-up (95.7% vs 85.7%, P = .042).[50]

DISCUSSION

Radical prostatectomy remains the most common treatment of localized prostate cancer.[51] More than 90% of radical prostatectomies in the United States are performed robotically.[52] Patient, surgeon, and technical modifications affect functional outcomes after RARP.[53] Surgeon experience and technique matters. Among 2000 prostatectomies performed by 11 high surgeons at a cancer center, the adjusted probability of erectile function 12 months after prostatectomy ranged from 10% to 50% after adjustment for patient age and baseline erectile function.[54]

Despite the widespread use of robotic surgery, the results for RARP compared with open prostatectomy do not seem to have improved in recent years. In fact, in centers where only a few robotic procedures are performed annually, the results may be worse as compared with open prostatectomy.[4,5] It is well known that even in the best hands, sexual function will be affected to some degree by prostatectomy. To effectively preserve the cavernous nerves during prostatectomy, it is crucial to minimize the mechanisms that can injure them, including transection, traction, and thermal injury. Traction and transection injuries can occur when there is excessive bleeding that obscures the surgeon's visualization or as a result of poorly positioned surgical instruments. Common examples of the latter include misplaced retractors during open prostatectomy and traction created by assistant suction during laparoscopic and robotic cases. The risk of thermal injury can be eliminated with the use of cautery-free techniques.[55] Furthermore, neuropraxia results from crush injuries of the NVB grasped with instruments or with excessive lateral retraction. It can be minimized with delicate surgical techniques that prevent stretching of the nerves.[16]

The absence of a standardized method for reporting results, as well as the paucity of randomized controlled trials, has posed a significant challenge for the systematic comparison of nerve-sparing techniques. The Sexual Health Inventory for Men, the EPIC 26-item as well as the International Index of Erectile Function are tools that have been used in the evaluation of pre- and post-operative sexual function. The use of different assessment tools and also the use of variable cut-off points could potentially introduce variability in the results of sexual potency. As new techniques and maneuvers are explored, attention to rigorous, randomized trials will be critical.

CLINICS CARE POINTS

- The goal of a RARP is to achieve cancer cure and minimize its impact on the quality of life and functional outcomes. The surgeon's experience, surgical technique, and presurgical characteristics of the patient are critical factors associated with a successful outcome after RARP.
- With current evidence, patients should be informed that robotic-assisted prostatectomy offers comparable outcomes in urinary and sexual function compared to the open or laparoscopic approach. These outcomes are more surgeon vs. approach dependent.
- Most patients with prostate cancer are candidates for a nerve-sparing technique which can generally be performed to some degree, even in men with extracapsular disease.
- The decision to perform a nerve-sparing RARP and the appropriate nerve-sparing plane is guided by preoperative sexual function, biopsy and MRI characteristics and tailored to goals of treatment through shared decision making.

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