The Impact of Retro-apical Urethral Dissection Approach Technique on Positive Surgical Margins in Robotic-assisted Laparoscopic Radical Prostatectomy: A Study in Thailand

Katunyou Mahamongkol, M.D., Malik Hajidae, M.D., Pubordee Aussavavirojekul, M.D., Thitipat Hansomwong, M.D., Sittiporn Srinualnad, M.D.

Division of Urology, Department of Surgery, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok, Thailand.

ABSTRACT

Objective: Among the various postoperative outcomes following robotic-assisted laparoscopic radical prostatectomy (RARP), positive surgical margins (PSMs) are a significant prognostic factor associated with biochemical recurrence (BCR). Many surgical techniques are available for RARP; however, the technique proposed in this study may improve surgical outcomes. This study aims to evaluate the incidence of post-operative PSMs in patients diagnosed with clinically localized prostate cancer at Siriraj Hospital using the retro-apical urethral dissection approach with a 30-degree-lens flip-up technique.

Materials and Methods: A retrospective review of 2,114 consecutive patients who underwent RARP with the conventional technique was conducted using Siriraj Hospital's database, from January 2007 to June 2022. Propensity score matching was employed to select a group of 284 men from the total cohort of 2,114 patients who underwent conventional radical prostatectomy (Group 1) for comparison against another group of 284 patients who underwent the retro-apical dissection technique (Group 2). The incidence of PSMs was then evaluated in each group.

Results: Of the 568 patients, PSMs were observed in 219 patients. The overall incidence of PSMs decreased from 128 cases (45.1%) in Group 1 to 91 cases (32.0%) in Group 2 (p-value <0.01). Similar results were seen in the subgroup of patients with pT2 staging who had PSMs (52 cases vs 24 cases, p-value <0.01). PSMs occurred mostly at the apex with a total of 112 cases (52.1%).

Conclusion: The retro-apical urethral dissection approach with a 30-degree-lens flip-up technique is associated with a lower risk of overall PSMs and the trend of apical PSMs, indicating its clinical significance.

Keywords: Positive surgical margins; retro-apical urethral dissection approach technique; prostate cancer; radical prostatectomy (Siriraj Med J 2023; 75: 827-834)

INTRODUCTION

Prostate cancer is the fourth most common cancer among men in Thailand.[1-3] Patients diagnosed with prostate cancer are informed about and provided with multiple treatment options, including active surveillance, surgery, hormonal therapy, and radiotherapy.[4-6]

Recently, various surgical techniques have become available for prostatectomy, such as open retropubic radical prostatectomy (RRP), laparoscopic radical prostatectomy (LRP), and robotic-assisted laparoscopic radical prostatectomy (RARP). RARP, which is known for its better postoperative outcomes compared to other techniques, has become increasingly popular.[7-10]

Corresponding author: Sittiporn Srinualnad
E-mail: sitsrinualnad@gmail.com
Received 30 August 2023 Revised 24 September 2023 Accepted 27 September 2023
ORCID ID:http://orcid.org/0000-0002-5118-7675
https://doi.org/10.33192/smj.v75i11.265055

All material is licensed under terms of the Creative Commons Attribution 4.0 International (CC-BY-NC-ND 4.0) license unless otherwise stated.

During RARP, urethral transection is one of the most significant steps that needs to be meticulously performed because the remaining urethral length helps maintain the continence mechanism. Therefore, it is crucial to secure the apical margin while preserving an adequate urethral length during the surgery to prevent complications such as positive surgical margins (PSMs) and urinary incontinence.[11,12]

Despite various modifications in surgical techniques over the decades[13-19], PSMs remain a challenging problem for urologists, as they are strongly associated with biochemical recurrence (BCR).[20-25] Failure to completely remove the tumors may occur due to various anatomical details and different surgical procedures.[26-30]

PSMs commonly occur at the prostatic apex, including in our institution.[30,31] This study aims to demonstrate the advantages of the retro-apical dissection technique, introduced by *Tewari et al.*, in reducing the incidence of PSMs in patients undergoing radical prostatectomy (RP). The technique helps improve the visualization of the prostatic apex for surgeons during the operation.[32]

MATERIALS AND METHODS

Patient population

Between January 2007 and June 2022, a retrospective review of medical records was conducted on patients diagnosed with localized prostate cancer who underwent radical prostatectomy (RP) at Siriraj Hospital. Based on the surgical technique used, the patients were classified into two groups: Patients who underwent the conventional urethral dissection technique (Group 1), while patients who underwent the retro-apical urethral dissection technique (Group 2) were included in the study.

A total of 2,114 men underwent RARP using the conventional urethral dissection technique. From this group, a statistical selection of 284 patients was made through propensity score matching. Several factors were taken into consideration to calculate the propensity score, including age, body mass index (BMI), American Society of Anesthesiologist (ASA) physical status classification, prostate-specific antigen (PSA), neurovascular bundle (NVB) sparing technique, operative time, estimated blood loss (EBL), prostatic weight, pathologic tumor stage (pT), Gleason score (GS), and the effect of androgen deprivation therapy (ADT).

Group 2 comprised 284 men who underwent RARP using retro-apical urethral dissection technique and were included in the study.

The operations were performed by experienced surgeons at Siriraj Hospital, each having conducted more than 100 cases of the procedure, and informed consent was obtained individually for surgical procedures. Patients with incomplete data or other types of cancer apart from prostate cancer were excluded from the study.

Demographic data, surgical technique, operative time, estimated blood loss, and pathological reports were collected through a review of electronic medical record review, and tumors were staged according to the 2002 TNM classification.

Surgical techniques

At our center, RARP was performed using the transperitoneal approach. The patient was positioned in the lithotomy or supine position with split legs and placed in the Trendelenburg position using the Da Vinci S, Si or Xi Surgical System (Intuitive Surgical, Sunnyvale, CA, USA) as preferred by the surgeons. A small incision was made above the umbilicus for the insertion of the camera, followed by three robotic ports and two assistant ports (5 mm and 12 mm). The placement of the three robotic ports depended on the system used, either in a dome or straight fashion. Both 0-degree and 30-degree lenses were used for the procedure, as depicted in Fig 1. The bladder was dropped to access the Retzius space. The endopelvic fascia was incised, and the prostate was freed from the levator ani muscle. A bladder neck transection was performed, and the anterior bladder wall was incised at the prostate-vesical junction until reaching the Foley catheter. The Foley catheter was then grasped and held anteriorly with the fourth arm. The posterior bladder neck was dissected until reaching the vas deferens and seminal vesicles. Once the seminal vesicles were mobilized freely, they were lifted anteriorly using the fourth arm. As the prostate was lifted, Denonvilliers' fascia was incised. The lateral pedicle of the prostate was divided with a Hem-O-Lok clip or electrocauterization. At this stage, the prostate was freed. To dissect the posterior and the apex of the prostate, two optional methods were available at our center. The first method (Group 1) involved dissecting from anterior to posterior until the urethra was dissected. The second method (Group 2) involved dissecting from the posterior aspect of the prostate anterogradely toward the urethra, using a flip-up 30-degree lens, as displayed in Fig 1, to identify the posterior prostate-urethral junction, before dissecting from both anterior and posterior approaches. Bladder neck reconstruction was performed if necessary, and urethra-vesical anastomosis was done.

Statistical analysis

Propensity scores were constructed based on known confounders, including age, BMI, ASA physical status

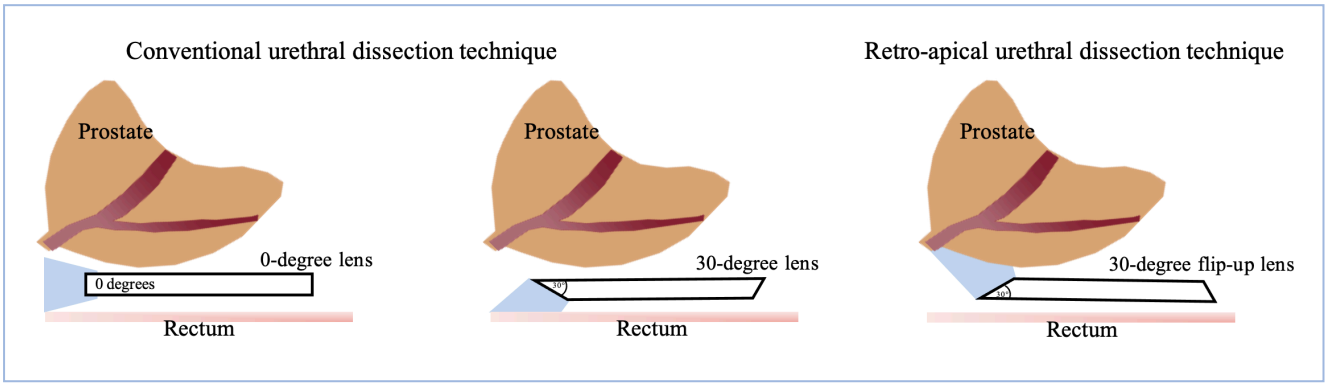


Fig 1. Comparison of Visualization Techniques
Conventional Technique: Utilizing either a 0-degree or 30-degree lens for dissection.
Retro-apical Technique: Employing a "flip-up" 30-degree lens, enhancing visibility of the prostatic apex.

classification, PSA level, operative time, EBL, prostatic weight, pT stage, GS, and ADT effect.

Demographic data were reported as mean and standard deviation for age and operative time, while median and interquartile ranges were used for BMI, PSA level, EBL, and prostatic weight. Independent t-tests were used to compare continuous data with a normal distribution, while the Mann-Whitney U test was used for non-normal distribution data. Chi-square and Fisher's exact tests were used for qualitative data.

Propensity score matching was performed using Python (Python Software Foundation, Wilmington, DE, USA) with the assistance of the following statistical packages: SciPy version 1.5.2 and Matplotlib version 3.3.2. Stata statistical software for Mac version 17.0 (StataCorp. 2021, College Station, TX, USA) and RStudio version 2023.06.2+561 (Posit Software. 2023, PBC, Boston, MA) were used for other statistical analyses. Statistical significance was defined as a p-value less than 0.05. Standardized mean differences of less than 0.1 was considered as covariate balance.

RESULTS

The results indicate that out of the 568 patients diagnosed with clinically localized prostate cancer, 284 underwent RARP using conventional techniques, while the other 284 underwent the retro-apical urethral dissection approach technique. Baseline characteristics between two groups were matched.

Patient characteristics

As shown in Table 1, the mean ages of 284 patients in Group 1 and 284 patients in Group 2 were 67.6 (±7.3) and 67.6 (±7.2) years, respectively. The median BMI was 24.15 in Group 1 and 24.24 in Group 2. Regarding the ASA classification, the majority of patients in both Group 1 and Group 2 were classified as ASA class II, with 190 (66.9%) and 192 (67.6%) patients, respectively. The median preoperative PSA level was 10.13 (range, 1.09-137.50) ng/dL in Group 1 and 9.50 (range, 0.70-267.00) ng/dL in Group 2. The mean operative time was 185.5 (±55.76) minutes for Group 1 and 182 (±55.6) minutes for Group 2. The median intraoperative blood loss was 300 (range, 20-1300) mL in Group 1 and 250 (range, 25-2100) mL in Group 2. The median prostatic weight was about 40 grams in both groups. The standardized mean difference of each covariate was less than 0.1.

Pathological outcome of patients

According to Table 2, the majority of patients in both groups had a GS of 3+4, with 108 (38.0%) in Group 1 and 115 (40.5%) in Group 2. The least common GS was 5+5 with 9 (3.2%) in Group 1 and 7 (2.5%) in Group 2. Additionally, some patients received preoperative ADT, which affected the ability to conclude the final GS. The proportion of patients with ADT effect was 16 (5.6%) in Group 1 and 13 (4.6%) in Group 2. The PSA levels at 1 year after surgery predominantly indicated undetectable PSA levels, with a total of 291 cases, comprising 138 (53.7%) out of 257 cases in Group 1 and 153 (61.9%) out of 232 cases in Group 2.

Among the 284 patients in each group, PSMs confirmed by the pathological report were found in 128 (45.1%) patients from Group 1 and 91 (32.0%) patients from Group 2. The rate of positive margins was significantly lower in Group 2 compared to Group 1 (p-value <0.01). The majority of patients in both groups were classified as pT2 stage, with 61.6% in the conventional group and 61.3% in the retro-apical group.

TABLE 1. Preoperative characteristics of patients diagnosed with clinically localized prostate cancer who underwent RARP.

Characteristics	Conventional dissection (N = 284)	Retro-apical dissection (N = 284)	p-value	SMD
Age[a], years	67.6 (±7.3)	67.6 (±7.2)	0.88	0.01
BMI[b], kg/m^2	24.15 (22.01, 26.33)	24.24 (22.31, 26.48)	0.46	<0.01
ASA[c]			0.98	<0.01
Class I	23 (8.1)	22 (7.7)		
Class II	190 (66.9)	192 (67.6)		
Class III	71 (25.0)	70 (24.6)		
PSA[b], ng/mL	10.13 (6.50, 16.00)	9.5 (6.00, 16.79)	0.11	0.03
NVB sparing technique[c]			0.70	0.05
None	213 (75.0)	22 (7.7)		
Unilateral	31 (10.9)	192 (67.6)		
Bilateral	40 (14.1)	70 (24.6)		
Operative time[a], minutes	185.5 (±55.76)	182.00 (±55.60)	0.46	0.06
EBL[b], mL	300 (150, 450)	250 (150, 400)	0.27	0.01
Prostatic weight[b], g	39.65 (30.72, 50.93)	39.70 (31.67, 50.00)	0.78	0.06

Abbreviations: RARP = Robotic-assisted Laparoscopic Radical Prostatectomy; SMD = Standardized mean differences; BMI = Body mass index; ASA = American Society of Anesthesiologist physical status classification; PSA = prostate-specific antigen; NVB = neurovascular bundle; EBL = estimated blood loss.

[a] Data are presented as mean ± standard deviation and p-value is calculated by independent samples T-test.

[b] Data are presented as median (interquartile range) and p-value is calculated by Mann-Whitney U test.

[c] Data are presented as n (%) and p-value is calculated by Chi-square or Fisher's exact test.

In terms of the location of PSMs, as shown in Table 3, a total of 215 out of 219 patients with PSMs were eligible for location analysis. PSMs were predominantly observed at the apex in both groups, with 71 (22%) out of a total of 323 sites in Group 1 and 41 (16.7%) out of a total of 246 sites in Group 2 (p-value 0.11).

From Table 4, in pT2 patients with PSMs, the retro-apical technique was also associated with a significantly lower overall PSMs rate compared to the conventional technique. Out of 175 cases in Group 1, 52 (29.7%) had PSMs, while in Group 2, out of 174 cases, only 24 (13.8%) had PSMs (p-value <0.01). Among patients staged as pT2 with PSMs, the majority had multiple PSMs, with 44 out of 52 patients (84.6%) in Group 1 and 22 out of 24 patients (91.7%) in Group 2 (p-value 0.49). Furthermore, the rate of apical PSMs decreased from 33 (30.6%) out of a total of 108 sites in Group 1 to 13 (22.4%) out of a total of 58 sites in Group 2 (p-value 0.26).

Similarly, as shown in Table 5, the retro-apical technique group exhibited a decrease in the overall rate of PSMs for pT3 patients with PSMs. In Group 1, out of 109 patients, 75 (68.8%) had PSMs, while in Group 2, out of 110 patients, 64 (58.2%) had PSMs (p-value 0.16). The rate of apical PSMs also decreased from 38 out of a total of 210 (18.1%) sites in Group 1 to 28 out of a total of 193 (14.5%) sites in Group 2 (p-value 0.33).

DISCUSSION

In the pursuit of performing RP, urologists strive to achieve complete tumor removal while preserving urinary and sexual function. PSMs are recognized as significant prognostic factors that can lead to early biochemical failure and tumor recurrence.[20-25] Consequently, numerous studies have been conducted to address these challenges.

In Thailand, several studies have explored the occurrence of PSMs in relation to pre-operative Magnetic Resonance Imaging (MRI) evaluation and clinicopathological characteristics of patients, with no significant differences observed among different surgical approaches RRP, LRP and RARP. In addition, PSMs are most commonly observed at the prostatic apex.[10,30,31]

TABLE 2. Pathological report and the rate of postoperative PSA level of patients with clinically localized prostate cancer who underwent RARP.

Characteristics	Conventional dissection (N = 284)	Retro-apical dissection (N = 284)	p-value	SMD
pT[c]			0.93	0.01
2	175 (61.6)	174 (61.3)		
3	109 (38.4)	110 (38.7)		
Gleason score[c]			0.97	0.08
3+3	54 (19.0)	49 (17.3)		
3+4	108 (38.0)	115 (40.5)		
4+3	45 (15.8)	48 (16.9)		
4+4	15 (5.3)	11 (3.9)		
4+5	35 (12.3)	35 (12.3)		
5+5	9 (3.2)	7 (2.5)		
ADT effect	16 (5.6)	13 (4.6)		
Surgical margin[c]			<0.01	
Positive	128 (45.1)	91 (32)		
Negative	156 (54.9)	193 (68)		
Post-operative PSA level[c,d]			<0.01	
Undetectable	138 (53.7)	153 (61.9)		
Low detectable	89 (34.6)	52 (21.1)		
Persistent	30 (11.7)	27 (10.9)		

Abbreviations: RARP = Robotic-assisted Laparoscopic Radical Prostatectomy; pT = pathologic tumor stage; GS = Gleason score; ADT = androgen deprivation therapy; PSA = prostate-specific antigen.
[a] Data are presented as mean ± standard deviation and the p-value is calculated by independent samples T-test.
[b] Data are presented as median (interquartile range) and the p-value is calculated by Mann-Whitney U test.
[c] Data are presented as *n* (%) and the p-value is calculated either by Chi-square or Fisher's exact test.
[d] The PSA level was assessed within 3 months after surgery. An undetectable PSA level is defined as a PSA level of less than 0.006 ng/ml. A low detectable PSA level is defined as a PSA level of 0.006 ng/ml and less than 0.1 ng/ml. A persistent PSA level is defined as a PSA level of 0.1 ng/ml or greater.

TABLE 3. Overall location and frequency of PSMs in 215 eligible patients with PSMs.

	Total	Conventional technique	Retro-apical technique	p-value
PSMs cases (n, %)	215	127 (59.1)	88 (40.9)	0.04
PSMs locations and frequency (n, %)				0.11
Apical	112 (19.7)	71 (22)	41 (16.7)	
Non-apical	457 (80.3)	252 (78)	205 (83.3)	
Total sites	569	323	246	

Abbreviation: PSMs = Positive surgical margins.
This table presents the number of overall patients with PSMs and the proportion of PSMs and their location in 215 eligible patients. The proportion of subgroups in "PSMs locations and frequency" is calculated based on the total number of sites (569 sites) where positive margins were found in each patient. For Group 1, there were a total of 323 positive margin sites, while for Group 2, there were a total of 246 positive margin sites. P-value was calculated using Chi-square test.

TABLE 4. Locations and frequency of PSMs in pT2 patients with PSMs.

	Total	Conventional technique	Retro-apical technique	p-value
Cases (n, %)				
pT2 patients	349	175 (50.1)	174 (49.9)	
pT2 patients with PSMs	76 (21.8)	52 (29.7)	24 (13.8)	<0.01
PSMs locations and frequency (n, %)				0.26
Apical	46 (27.7)	33 (30.6)	13 (22.4)	
Non-apical	120 (73.6)	75 (69.4)	45 (77.6)	
Total sites	166	108	58	

Abbreviations: pT = pathologic tumor stage; PSMs = Positive surgical margins.
This table presents the number and proportion of patients having pT2 disease and PSMs (out of 175 patients in Group 1 and out of 174 patients in Group 2). The table also provides the proportion of PSMs and their locations in a group of 76 patients diagnosed with PSMs and pT2 stage. The proportion of subgroups in "PSMs locations and frequency" is calculated based on the total number of sites (166 sites) where positive margins were found in each patient. For Group 1, there were a total of 108 positive margin sites, while for Group 2, there were a total of 58 positive margin sites. P-value was calculated using Chi-square test.

TABLE 5. Locations and frequency of PSMs in pT3 patients with PSMs.

	Total	Conventional technique	Retro-apical technique	p-value
Cases (n, %)				
pT3 patients	218	109 (49.5)	110 (50.5)	
pT3 patients with PSMs	139 (63.8)	75 (68.8)	64 (58.2)	0.16
PSMs locations and frequency (n, %)				0.33
Apical	66 (16.4)	38 (18.1)	28 (14.5)	
Non-apical	337 (83.6)	172 (81.9)	165 (85.5)	
Total sites	403	210	193	

Abbreviations: pT = pathologic tumor stage; PSMs = Positive surgical margins.
This table presents the number of patients having pT3 disease and PSMs (out of 109 patients in Group 1 and out of 109 patients in Group 2). The table also provides the proportion of PSMs and their locations in a group of 139 patients diagnosed with PSMs and pT3 stage. The proportion of subgroups in "PSMs locations and frequency" is calculated based on the total number of sites (403 sites) where positive margins were found in each patient. For Group 1, there were a total of 210 positive margin sites, while for Group 2, there were a total of 193 positive margin sites. P-value was calculated using Chi-square test.

The retro-apical technique shows a promising trend in reducing both overall PSMs and apical PSMs rate. At our institution, two techniques were used depending on surgeons' preferences: the conventional and retro-apical techniques. According to *Tewari et el.*, the retro-apical urethral dissection technique with RARP significantly lowered the rate of overall PSMs and apical PSMs.[7,32] Similarly, in our present study, we observed a substantial decline in both overall and apical PSMs rate within the retro-apical group. This improvement can be attributed to the enhanced visibility provided by a flip-up 30-degree lens, which offers a clearer view of the prostatic apex and enables more thorough removal of apical tumors.

Despite the observed trend not being statistically significant, concerning the rate of apical positive margins, a noticeable downward trend was observed in both pT2 and pT3 groups (8.2% and 10.6% decrease). However, the statistical insignificant may result from the rate which was determined as the proportion of positive margin sites, rather than the number of cases. The increase in

the percentages of PSMs at other sites may have also contributed to the lack of statistical significance in our findings.

The high rate of PSMs in our study may be attributed to the combined prevalence of pT2 and pT3 cases. However, when we compared the conventional and retro-apical techniques while controlling for confounding factors, the PSMs rate in pT2 patients fell within the typical range (29.7% and 13.8%), while a higher rate was observed in pT3 patients (68.8% and 58.2%), according to a previous study.[33]

Known by unfavorable consequences following PSMs, there are numerous treatment options available, including active surveillance, hormonal therapy, radiation, and chemotherapy. Early post-operative PSA levels, assessed within 3 months after surgery, is one of the strong predictors for BCR, and is classified into 3 groups: undetectable, low detectable, and persistent.[34-36] In the current study, it was observed that the retro-apical techniques yield a higher rate of undetectable PSA levels, leading to a more favorable outcome.

Limitations

Our findings should be considered in the context of study's limitations. Firstly, it's worth acknowledging that, as a retrospective study, the visualization provided by different versions of the DaVinci system across different time periods may have a minor impact on surgical margins. Among the Da Vinci versions used, Da Vinci version S may offer slightly lower resolution compared to the other two versions, but no substantial impact on the surgical procedure was observed. Furthermore, no difference in visualization was noted between Da Vinci version Si and Xi.

Secondly, our initial sample size calculation was based on an analysis of overall PSMs, and it may not have provided sufficient statistical power to detect differences in subgroups related to the specific sites of PSMs. Therefore, it is advisable to recruit a larger sample size to improve the statistical robustness in future study. Additionally, it is important to note that other potential confounding factors, such as PSA density (PSAD), was not included in matching process of this study. Since both PSA and prostate volume were matched, presuming that PSAD would not significantly alter the outcomes.

Thirdly, our study was conducted at a single tertiary center, which restricts the generalizability of our results to a broader population. Furthermore, it's crucial to consider the learning curve of surgeons in interpreting our findings. Further studies should be conducted to enhance the validity and generalizability.

CONCLUSION

The retro-apical dissection technique in RARP provides better visualization of the apical aspect on the posterior side of the prostate, enabling surgeons to achieve more complete tumor removal. This technique has demonstrated a reduction in the incidence of both overall PSMs and potentially at the apical area when compared to conventional techniques.

ACKNOWLEDGEMENTS

The authors would like to express gratitude to Miss Jitsiri Chaiyatho, Miss Bongkoch Prakittikul, and the coordinators at Siriraj Hospital for their valuable contributions to this study.

REFERENCES

1. The Global Cancer Observatory. Prostate cancer fact sheet [Internet]. Lyon, France: International Agency for Research on Cancer, World Health Organization; 2020 [cited 2023 Sep 9]. Available from: https://gco.iarc.fr/today/data/factsheets/cancers/27-Prostate-fact-sheet.pdf.
2. National Cancer Institution of Thailand. Hospital-based cancer registry 2021 [Internet]. Bangkok, Thailand: Ministry of Public Health; 2022 [cited 2023 Sep 9]. Available from: https://www.nci.go.th/e_book/hosbased_2564/index.html.
3. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A, et al. Global Cancer Statistics 2020: GLOBOCAN Estimates of Incidence and Mortality Worldwide for 36 Cancers in 185 Countries. CA Cancer J Clin. 2021;71(3):209-49.
4. Eastham JA, Auffenberg GB, Barocas DA, Chou R, Crispino T, Davis JW, et al. Clinically Localized Prostate Cancer: AUA/ASTRO Guideline, Part I: Introduction, Risk Assessment, Staging, and Risk-Based Management. J Urol. 2022;208(1):10-8.
5. Eastham JA, Auffenberg GB, Barocas DA, Chou R, Crispino T, Davis JW, et al. Clinically Localized Prostate Cancer: AUA/ASTRO Guideline, Part II: Principles of Active Surveillance, Principles of Surgery, and Follow-Up. J Urol. 2022;208(1):19-25.
6. Eastham JA, Auffenberg GB, Barocas DA, Chou R, Crispino T, Davis JW, et al. Clinically Localized Prostate Cancer: AUA/ASTRO Guideline. Part III: Principles of Radiation and Future Directions. J Urol. 2022;208(1):26-33.
7. Tewari A, Sooriakumaran P, Bloch DA, Seshadri-Kreaden U, Hebert AE, Wiklund P. Positive surgical margin and perioperative complication rates of primary surgical treatments for prostate cancer: a systematic review and meta-analysis comparing retropubic, laparoscopic, and robotic prostatectomy. Eur Urol. 2012;62(1):1-15.
8. Ramirez D, Zargar H, Caputo P, Kaouk JH. Robotic-assisted laparoscopic prostatectomy: An update on functional and oncologic outcomes, techniques, and advancements in technology. J Surg Oncol. 2015;112(7):746-52.
9. Pohle M, Magheli A, Fischer T, Kempkensteffen C, Busch J, Cash H, et al. The Effect of Evolving Strategies in the Surgical Management of Organ-Confined Prostate Cancer: Comparison of Data from 2005 to 2014 in a Multicenter Setting. Adv Ther. 2017;34(2):576-85.

10. Srinualnad S, Hansomwong T, Aussavavirojekul P, Saksirisampant P. Paradigm shift from open surgery to minimally invasive surgery in three approaches for radical prostatectomy: comparing outcomes and learning curves. Siriraj Med J. 2022;74(10):618-26.
11. Wagaskar VG, Mittal A, Sobotka S, Ratnani P, Lantz A, Falagario UG, et al. Hood Technique for Robotic Radical Prostatectomy-Preserving Periurethral Anatomical Structures in the Space of Retzius and Sparing the Pouch of Douglas, Enabling Early Return of Continence Without Compromising Surgical Margin Rates. Eur Urol. 2021;80(2):213-21.
12. Arroyo C, Martini A, Wang J, Tewari AK. Anatomical, surgical and technical factors influencing continence after radical prostatectomy. Ther Adv Urol. 2019;11:1756287218813787.
13. Ahlering TE, Eichel L, Edwards RA, Lee DI, Skarecky DW. Robotic radical prostatectomy: a technique to reduce pT2 positive margins. Urology. 2004;64(6):1224-8.
14. Laven BA, Alsikafi NF, Yang XJ, Brendler CB. Minor modifications in apical dissection of radical retropubic prostatectomy in patients with clinical stage T2 prostate cancer reduce positive surgical margin incidence. Urology. 2004;63(1):95-8.
15. Poulakis V, de Vries R, Dillenburg W, Altmansberger HM, Becht E. Laparoscopic radical prostatectomy: impact of modified apical and posterolateral dissection in reduction of positive surgical margins in patients with clinical stage T2 prostate cancer and high risk of extracapsular extension. J Endourol. 2006;20(5):332-9.
16. Guru KA, Perlmutter AE, Sheldon MJ, Butt ZM, Zhang S, Tan W, et al. Apical margins after robot-assisted radical prostatectomy: does technique matter? J Endourol. 2009;23(1):123-7.
17. Namiki K, Kasraeian A, Yacoub S, Rosser CJ. Blunt apical dissection during anatomic radical retropubic prostatectomy. BMC Res Notes. 2009;2:20.
18. Sasaki H, Miki J, Kimura T, Sanuki K, Miki K, Takahashi H, et al. Lateral view dissection of the prostato-urethral junction to reduce positive apical margin in laparoscopic radical prostatectomy. Int J Urol. 2009;16(8):664-9.
19. Ou YC, Hung SW, Wang J, Yang CK, Cheng CL, Tewari AK. Retro-apical transection of the urethra during robot-assisted laparoscopic radical prostatectomy in an Asian population. BJU Int. 2012;110(2 Pt 2):E57-63.
20. Zhang L, Wu B, Zha Z, Zhao H, Jiang Y, Yuan J. Positive surgical margin is associated with biochemical recurrence risk following radical prostatectomy: a meta-analysis from high-quality retrospective cohort studies. World J Surg Oncol. 2018;16(1):124.
21. Kim M, Yoo D, Pyo J, Cho W. Clinicopathological significances of positive surgical resection margin after radical prostatectomy for prostatic cancers: a meta-analysis. Medicina (Kaunas). 2022;58(9):1251.
22. Meeks JJ, Eastham JA. Radical prostatectomy: positive surgical margins matter. Urol Oncol. 2013;31(7):974-9.
23. Eastham JA, Kuroiwa K, Ohori M, Serio AM, Gorbonos A, Maru N, et al. Prognostic significance of location of positive margins in radical prostatectomy specimens. Urology. 2007;70(5):965-9.
24. Martini A, Gandaglia G, Fossati N, Scuderi S, Bravi CA, Mazzone E, et al. Defining Clinically Meaningful Positive Surgical Margins in Patients Undergoing Radical Prostatectomy for Localised Prostate Cancer. Eur Urol Oncol. 2021;4(1):42-8.
25. Beckmann KR, O'Callaghan ME, Vincent AD, Moretti KL, Brook NR. Clinical outcomes for men with positive surgical margins after radical prostatectomy—results from the South Australian Prostate Cancer Clinical Outcomes Collaborative community-based registry. Asian Journal of Urology. 2022.
26. Kang SG, Schatloff O, Haidar AM, Samavedi S, Palmer KJ, Cheon J, et al. Overall rate, location, and predictive factors for positive surgical margins after robot-assisted laparoscopic radical prostatectomy for high-risk prostate cancer. Asian J Androl. 2016;18(1):123-8.
27. Matikainen MP, von Bodman CJ, Secin FP, Yunis LH, Vora K, Guillonneau B, et al. The depth of the prostatic apex is an independent predictor of positive apical margins at radical prostatectomy. BJU Int. 2010;106(5):622-6.
28. Yao A, Iwamoto H, Masago T, Morizane S, Honda M, Sejima T, et al. The role of staging MRI in predicting apical margin positivity for robot-assisted laparoscopic radical prostatectomy. Urol Int. 2014;93(2):182-8.
29. Coelho RF, Chauhan S, Orvieto MA, Palmer KJ, Rocco B, Patel VR. Predictive factors for positive surgical margins and their locations after robot-assisted laparoscopic radical prostatectomy. Eur Urol. 2010;57(6):1022-9.
30. Saksirisampant P, Nualyong C, Srinualnad S, Leewansangtong S, Taweemonkongsap T, Jitpraphai S, et al. Positive surgical margins after radical prostatectomy: Associated risk factors in Thai prostate cancer patients. J Med Assoc Thai.2020;103(5):68-74.
31. Hansomwong T, Saksirisampant P, Isharwal S, Aussavavirojekul P, Woranisarakul V, Jitpraphai S, et al. Role of preoperative magnetic resonance imaging on the surgical outcomes of radical prostatectomy: Does preoperative tumor recognition reduce the positive surgical margin in a specific location? Experience from a Thailand Prostate Cancer Specialized Center. Asian J Urol. [In press] 2022. doi:10.1016/j.ajur.2022.05.012
32. Tewari AK, Srivastava A, Mudaliar K, Tan GY, Grover S, El Douaihy Y, et al. Anatomical retro-apical technique of synchronous (posterior and anterior) urethral transection: a novel approach for ameliorating apical margin positivity during robotic radical prostatectomy. BJU Int. 2010;106(9):1364-73.
33. Kang SG, Shim JS, Onol F, Bhat KRS, Patel VR. Lessons learned from 12,000 robotic radical prostatectomies: Is the journey as important as the outcome? Investig Clin Urol. 2020;61(1):1-10.
34. Koulikov D, Mohler MC, Mehedint DC, Attwood K, Wilding GE, Mohler JL. Low detectable prostate specific antigen after radical prostatectomy--treat or watch? J Urol. 2014;192(5):1390-6.
35. Kang JJ, Reiter RE, Steinberg ML, King CR. Ultrasensitive prostate specific antigen after prostatectomy reliably identifies patients requiring postoperative radiotherapy. J Urol. 2015;193(5):1532-8.
36. Milonas D, Venclovas Z, Sasnauskas G, Ruzgas T. The Significance of Prostate Specific Antigen Persistence in Prostate Cancer Risk Groups on Long-Term Oncological Outcomes. Cancers. 2021;13(10):2453.