

Comparative Study on the Application Value of Transperineal Prostate Combined Biopsy and Transrectal Prostate Systematic Biopsy in Diagnosing Prostate Cancer in Patients with Different PSA Zones

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Purpose: This study aimed to compare the effects of transperineal prostate combined biopsy (TP-CB) and transrectal prostate systematic biopsy (TR-SB) on the detection rate and safety of prostate cancer in patients with prostate-specific antigen (PSA) gray zone, PSA levels of 10~20 ng/mL, and 20~40 ng/mL, and explore the comparative value of their applications.

Materials and Methods: We collected 243 samples from patients with PSA \leq 40 ng/mL who underwent prostate biopsy. All patients were divided into two groups according to different patterns of prostate biopsy. The detection rates of prostate cancer and clinically significant prostate cancer (CsPCa) in patients with PSA levels of 4~10, 10~20, and 20~40 ng/mL were compared between two different biopsy methods, surgical conditions, and the incidence of complications.

Results: The rate of a positive prostate cancer biopsy was significantly higher in TP-CB than in TR-SB ($P < 0.05$). Further subgroup analyses revealed no statistical significance in the rate of positive prostate cancer biopsy in patients with PSA levels of 4~10 and 20~40 ng/mL between the two groups ($P > 0.05$). However, patients with PSA levels of 10~20 ng/mL in the TP-CB group exhibited a higher detection rate ($P < 0.05$), with CsPCa accounting for a higher proportion. The TP-CB and TR-SB groups did not exhibit a significant difference in surgical conditions or overall complication rates ($P > 0.05$). However, the TR-SB group exhibited a higher risk of postoperative febrile infection than the TP-CB group ($P < 0.05$).

Conclusion: For patients with PSA in the 'sub-gray zone' (10~20 ng/mL), TP-CB has a better diagnostic and application value and is more suitable for clinical promotion.

Keywords: prostate; biopsy; transperineal; transrectal; prostate cancer

INTRODUCTION

Prostate cancer (PCa) is the most common malignant tumor of the male genitourinary system. It has the first-highest estimated incidence rate and the second-highest mortality rate among all malignant tumors in men, according to the 2024 cancer statistics report⁽¹⁾. Morbidity and related mortality of PCa are rapidly increasing in Asia⁽²⁾. Furthermore, PCa is characterized by an insidious onset, and patients with PCa frequently present without symptoms during the early stages of the disease. The lives of patients with PCa may be at substantial risk because the cancer may have already progressed to an advanced stage by the time clinical manifestations become obvious. Therefore, an early and definitive diagnosis of PCa can improve its treatment efficacy and prognosis.

Prostate-specific antigen (PSA) is a crucial biological marker for PCa screening. The gold standard for diagnosing PCa is prostate biopsy, which is necessary for patients with abnormal PSA levels to obtain tissue

specimens for pathological examination. The detection rate of PCa is relatively low for patients with PSA gray zone (4~10 ng/mL). Despite the diagnosis of PCa, a high percentage of cases are characterized by clinically insignificant PCa^(3,4). When PSA levels exceed 20 ng/mL, the guideline recommends a bone scan because of the high probability of bone metastases in these patients⁽⁵⁻⁷⁾. Enhancing the diagnostic accuracy for patients with PSA levels of 10~20 ng/mL is imperative. This is because the positive rate of PCa biopsy and the percentage of clinically significant PCa (CsPCa) are relatively high, while the incidence of bone metastasis is relatively low⁽⁸⁾, potentially enabling more patients to meet the criteria for curative treatment⁽⁹⁾. Improving the detection rate of PCa biopsy in patients with PSA of 10~20 ng/mL is crucial for the clinical diagnosis and subsequent treatment of these patients.

The different methods and routes of prostate biopsy have an essential impact on PCa detection rates and complications. The most frequently employed clinical practice method was ultrasound-guided systematic

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Table 1. Comparison of patients' general information

	TR-SB (n=128)	TP-CB (n=115)	t/Z-Value	P-Value	Difference 95% CI	Levene's test
Age	68.39 ± 9.46	70.41 ± 7.58	1.821	0.070	-4.20 ~ 0.17	0.058
PSA (ng/mL)	14.28 (8.87, 23.53)	15.74 (10.89, 22.10)	1.066	0.287	-3.22 ~ 0.97	-
Prostate Volume (mL)	44.51 (31.58, 48.48)	50.46 (36.46, 62.17)	1.912	0.056	-9.99 ~ 0.11	-
PSA 4~10 ng/mL	n=38	n=23				
Age	66.34 ± 8.40	69.09 ± 9.16	1.195	0.237	-7.34 ~ 1.85	0.337
PSA (ng/mL)	7.12 ± 1.71	6.40 ± 1.64	1.611	0.113	-1.73 ~ 1.60	0.962
Prostate Volume (mL)	39.27 (29.27, 48.77)	43.47 (23.47, 78.07)	0.551	0.582	-18.50 ~ 7.94	-
PSA 10~20 ng/mL	n=53	n=58				
Age	68.62 ± 10.56	69.67 ± 7.04	0.610	0.543 ^a	-4.47 ~ 2.37	0.005
PSA (ng/mL)	14.39 ± 2.32	14.88 ± 2.71	0.993	0.323	-1.43 ~ 0.48	0.083
Prostate Volume (mL)	44.60 (29.59, 63.82)	47.39 (38.29, 60.71)	0.767	0.443	-10.55 ~ 4.71	-
PSA 20~40 ng/mL	n=37	n=34				
Age	70.16 ± 8.65	72.56 ± 7.08	1.272	0.208	-6.16 ~ 1.36	0.179
PSA (ng/mL)	29.49 ± 5.05	29.31 ± 6.09	0.141	0.888	-2.45 ~ 2.83	0.295
Prostate Volume (mL)	50.19 (41.43, 60.44)	56.25 (42.59, 67.36)	1.462	0.144	-13.67 ~ 2.73	-

^aCorrected t-test

biopsy via the transrectal route. A transperineal prostate biopsy has received increasing attention in clinical practice because of its high detection rate and low risk of infection⁽¹⁰⁾.

Furthermore, targeted prostate biopsy is currently a precise and effective method for PCa diagnosis. However, the difference in PCa and CsPCa detection rates between targeted biopsy and systematic biopsy when PSA is < 20 ng/mL is controversial^(11,12). However, targeted combined systematic biopsy can utilize the advantages of both methods simultaneously, improving the PCa detection rate⁽¹³⁾.

This study aimed to compare the efficacy of transperineal prostate combined biopsy (TP-CB) and conventional transrectal prostate systematic biopsy (TR-SB) for PCa in patients with PSA gray zone, PSA levels of 10~20 ng/mL, and 20~40 ng/mL to provide a clinical and theoretical foundation for improving the diagnosis and subsequent treatment of PCa in patients with this PSA zone.

MATERIALS AND METHODS

Data Source

This prospective cohort study divided patients into the TP-CB and TR-SB groups. The primary observational factor was the PCa detection rate. According to the relevant research and pre-test results, the PCa detection rate was approximately 56% for TP-CB and approximately

38% for TR-SB. Setting $\alpha = 0.05$ and $1 - \beta = 0.80$. Using PASS 15 software to calculate the sample size of the two groups. N1 = N2 = 117 cases.

This study collected clinical data from 285 patients with PSA at 4~40 ng/mL who underwent prostate biopsy at the Department of Urology of Xuzhou Central Hospital Medical Ethics Committee between June 2022 and February 2024. This study was approved by the Xuzhou Central Hospital Medical Ethics Committee (XZXY-LK-20230523-078), and all patients provided written informed consent.

Inclusion and exclusion criteria

Inclusion criteria:

- (1) Patients who provided written informed consent;
- (2) patients over 18 years old who met the indications for prostate biopsy: (i) total PSA (tPSA) > 10 ng/mL; (iii) suspicious prostate nodule detected using rectal finger-printing; (iii) suspicious lesion detected using rectal ultrasound, MRI, or PSMA PET/CT; (iv) f/tPSA < 0.16 at tPSA 4~10 ng/mL or PSA density > 0.15 ng/mL;
- (3) patients who were mentally competent, could understand all study requirements, and cooperate with their physician;
- (4) patients who were willing to undergo all treatment and follow-up as required by the protocol.

Exclusion criteria:

- (1) tPSA ≥ 40 ng/mL;
- (2) patients with a previous surgical history of prostatectomy;
- (3) pa-

Table 2. Comparison of PCa, CsPCa detection rate and CsPCa proportion between the two groups.

	TR-SB (n=128) n (%)	TP-CB (n=115) n (%)	χ ² -Value	P-Value	OR 95% CI
PCa [cases (%)]	52 (40.6)	64 (55.7)	5.483	0.019	0.33 ~ 0.91
CsPCa [cases (%)]	34 (26.6)	53 (46.1)	10.047	0.002	0.25 ~ 0.72
CsPCa ratio (%)	65.4	82.8	4.647	0.031	0.16 ~ 0.93
PSA 4~10 ng/mL	n=38	n=23			
PCa [cases (%)]	9 (23.7)	7 (30.4)	0.337	0.561	0.22 ~ 2.27
CsPCa [cases (%)]	4 (10.5)	5 (21.7)	0.679	0.410 ^a	0.10 ~ 1.78
CsPCa ratio (%)	44.4	71.4	-	0.358 ^b	0.04 ~ 2.62
PSA 10~20 ng/mL	n=53	n=58			
PCa [cases (%)]	21(39.6)	34 (58.6)	3.998	0.046	0.22 ~ 0.99
CsPCa [cases (%)]	12 (22.6)	28 (48.3)	7.895	0.005	0.14 ~ 0.72
CsPCa ratio (%)	57.1	82.3	4.160	0.041	0.08 ~ 0.98
PSA 20~40 ng/mL	n=37	n=34			
PCa [cases (%)]	22 (59.4)	23 (67.6)	0.512	0.474	0.27 ~ 1.86
CsPCa [cases (%)]	18 (48.6)	20 (58.8)	0.737	0.390	0.26 ~ 1.70
CsPCa ratio (%)	81.8	86.9	-	0.699 ^b	0.13 ~ 3.43

^aYates's correction for continuity

^bFisher's exact test

Table 3. Comparison of CsPCa detection rate in patients of different age and prostate volume between the two groups

	CsPCa detected by TR-SB (n=34) n (%)	CsPCa detected by TP-CB (n=53) n (%)	χ^2 -Value	P-Value	OR 95% CI
Age					
< 65	9 (26.5)	16 (30.2)	0.140	0.708	0.32 ~ 2.18
65 ~ 75	13 (38.2)	21 (39.6)	0.017	0.897	0.39 ~ 2.28
> 75	12 (35.3)	16 (30.2)	0.247	0.619	0.51 ~ 3.15
Prostate Volume (mL)					
< 40	12 (35.3)	14 (26.4)	0.779	0.377	0.60 ~ 3.86
40 ~ 70	16 (47.1)	29 (54.7)	0.486	0.486	0.31 ~ 1.75
> 70	6 (17.6)	10 (18.9)	0.021	0.886	0.30 ~ 2.82

tients with severe hemorrhoids, anal stenosis, bleeding tendencies, acute prostate inflammation, perineal skin infection, and other diseases in the rectum or perineum; (4) patients diagnosed with diabetes, systemic autoimmune diseases, and other diseases; (5) patients considered unsuitable for participation in clinical trials by the investigator.

Surgical method

Transrectal prostate systematic biopsy (TR-SB)

Rectal punctures were performed following preoperative fasting, glycerin enemas for intestinal tract cleansing, and antimicrobial treatment. The patients were placed in the left lateral position during the procedure. The anus was fully exposed, and the perineum and anal area were routinely disinfected. After preparing 10 mL of 1% lidocaine for local anesthesia, the biopsy was conducted under ultrasound guidance. One needle was inserted on each side of the gland near the midline and at the lateral base, middle, and tip of the peripheral zone. Gauze compression was applied to the anus to stop post-biopsy bleeding (Figure 1).

Transperineal prostate combined biopsy (TP-CB)

The perineum and surrounding skin of the patients were cleaned and sterilized. Each patient was placed in the lithotomy position with immobilized legs. After disinfecting the perineum, 10 mL of 1% lidocaine was injected at a puncture point 2 cm above the anus at the midline of the paracentral opening of approximately 1 cm. An anesthetic nerve block was performed in the perineum. Following the successful administration of local anesthesia, the BK dual-plane probe ultrasound was used to guide the biopsy, and three needles were selected to target the suspicious site. The perineum was routinely sterilized and pressure bandaged post-biopsy (Figure 2).

Observation Indexes

This study aimed to compare PCa and CsPCa detection rates in patients with PSA levels of 4~10, 10~20, and 20~40 ng/mL using TP-CB and TR-SB methods. We

observed and compared the surgical situation and pain level of the two groups of patients with different biopsy methods, including surgical time, bleeding, and surgical visual analog scale (VAS) pain score. Additionally, the study compared the complications in the two groups, including pain, fever, hematuria, urinary retention, and rectal bleeding, to assess the probability and risk of complications in both groups. The proportion of patients with CsPCa was compared between those with PSA levels of 4~10, 10~20, and 20~40 ng/mL.

Postoperatively, patients were observed for urinary retention, hematuria, pain in the operative area, and fever from infection. Indwelling urinary catheters were inserted for patients with urinary retention, and they also received α -receptor-antagonist drugs. A three-chamber catheter was left for traction and compression, or irrigation under cystoscopy, to stop bleeding in patients with severe hematuria. Patients with pain in the operative area were treated with analgesia and other symptomatic treatments when blood and mid-stream urine cultures and drug sensitivity tests were performed for patients with postoperative urinary tract infection, generalized fever, and sepsis, and appropriate anti-infective drugs, including cephalosporins or quinolone antibiotics, were administered. Patients were discharged within 3 days if there were no obvious postoperative complications.

Statistical analysis

Statistical Package for the Social Sciences software version 27.0 was utilized for data analysis. The Shapiro-Wilk test and Q-Q plot were used to determine normal distribution. Normally distributed measurements are represented as the mean \pm standard deviation. Non-normally distributed data are expressed as Md (P25, P75). We used Levene's test to determine the homogeneity of variance between two sets of data, and student's t-test or rank-sum test was used for comparisons. Count data are expressed as n (%), and χ^2 test was used to analyze and compare the differences if sample size $n \geq 40$ and expectation $T \geq 5$. When $n \geq 40$ and for any minimum $1 \leq T < 5$, using the Yates's correction for continuity.

Table 4. Comparison of prostate aspiration procedures

	Time (min)			Ridit	Difference 95% CI	Z-Value	P-Value
	< 8	8 ~ 12	> 12				
TR-SB (n=128) n(%)	45 (35.2)	76 (59.4)	7 (5.4)	0.498	0.44 ~ 0.54	0.605	0.545
TP-CB (n=115) n(%)	43 (37.4)	54 (46.9)	18 (15.6)	0.512	0.46 ~ 0.57		
	Bleeding volume (mL)						
	< 2	2 ~ 3	> 3				
TR-SB (n=128) n(%)	101 (80.8)	23 (17.9)	4 (3.1)	0.493	0.44 ~ 0.54	0.386	0.700
TP-CB (n=115) n(%)	87 (75.6)	26 (22.6)	2 (1.7)	0.508	0.46 ~ 0.56		
	VAS (score)						
	≤ 3	4 ~ 5	≥ 6				
TR-SB (n=128) n(%)	37 (28.9)	82 (64.1)	9 (7.0)	0.488	0.44 ~ 0.54	0.685	0.493
TP-CB (n=115) n(%)	28 (24.3)	65 (56.5)	12 (10.4)	0.514	0.46 ~ 0.57		

Table 5. Comparison of VAS pain scores in different parts of prostate biopsy.

	Probe insertion (score)			Ridit	Difference 95% CI	Z-Value	P-Value
	≤ 1	2	≥ 3				
TR-SB (n=128)n(%)	94 (73.4)	29 (22.7)	5 (3.9)	0.479	0.43 ~ 0.53	1.213	0.225
TP-CB (n=115)n(%)	73 (63.5)	40 (34.8)	2 (1.7)	0.524	0.47 ~ 0.58		
	Local anesthesia (score)						
	≤ 3	4	≥ 5				
TR-SB (n=128)n(%)	52 (40.6)	59 (46.1)	17 (13.2)	0.453	0.40 ~ 0.50	2.655	0.008
TP-CB (n=115)n(%)	30 (26.1)	56 (48.7)	29 (25.2)	0.552	0.49 ~ 0.60		
	Biopsy procedure (score)						
	≤ 2	3	≥ 4				
TR-SB (n=128)n(%)	51 (39.8)	72 (56.2)	5 (3.9)	0.488	0.44 ~ 0.54	0.678	0.498
TP-CB (n=115)n(%)	42 (36.5)	65 (56.5)	8 (7.0)	0.513	0.46 ~ 0.57		

When $n < 40$ or at least one $T < 1$ or more than 20% of expectation $T < 5$, using Fisher's exact test. Ridit analysis was used for comparison of quantitative data grouped by rank.

RESULTS

Comparison of general information between patients in the TR-SB group and TP-CB groups Based on the inclusion and exclusion criteria, 243 patients were included (Table 1). No statistically significant differences were observed between TR-SB and TP-CB groups based on age, PSA values, and prostate volume (all $P > 0.05$).

Comparison of PCa detection rate, and CsPCa ratio between TR-SB group and TP-CB groups

Table 2 shows that the positive rate of PCa biopsy was higher in the TP-CB group than in the TR-SB group ($P < 0.05$). No statistically significant differences were observed between the PCa detection rate and the proportion of CsPCa in different PSA-level subgroups for the two modalities ($P > 0.05$). However, in patients with PSA levels between 10 and 20 ng/mL, the TP-CB group exhibited a higher positive rate of PCa biopsy and proportion of CsPCa than the TR-SB group, which was statistically significant ($P < 0.05$).

Comparison of CsPCa detection rate in patients of different ages and Prostate Volume between the two groups.

Table 3 shows that no significant correlation between different ages and prostate volumes for csPCa detection rate in TR-SB group and TP-CB groups ($P > 0.05$).

Comparison of the indicators of the surgical conditions of patients in the TR-SB group and TP-CB groups

Tables 4 and 5 show that the difference in surgery duration and intraoperative bleeding between the two groups was statistically non-significant ($P > 0.05$). Additionally, no statistically significant difference was observed in the overall VAS score, probe insertion VAS score, or VAS score of the puncture process among patients in the two groups ($P > 0.05$). However, there was

a statistically significant difference in the VAS score of the anesthesia administration process among patients in TR-SB and TP-CB groups ($P < 0.05$).

Comparison of the incidence of complications between patients in the TR-SB group and TP-CB group

No statistically significant differences were observed among patients in TR-SB and TP-CB groups based on complication rates ($P > 0.05$). However, four patients in the TR-SB group developed urinary retention with hematuria (Table 6).

DISCUSSION

PCa is common in the genitourinary system. PCa-specific markers are not PSA levels, despite their frequent association with the pathological grade of PCa^(14,15). Prostate biopsy is still necessary for the definitive diagnosis of PCa in patients with suspected PCa. The biopsy positivity rate for PCa is low in patients with low PSA levels, approximately 30% in PSA gray zone⁽¹⁶⁾. Additionally, approximately 20%~30% of patients with PSA levels ≤ 20 ng/mL develop bone metastases^(17,18), Curative treatment is essential for most patients without bone metastases at this PSA level. Therefore, improving the rate of positive PCa biopsy in patients with PSA levels of ≤ 20 ng/mL is crucial. We propose that 'sub-gray zone' PSA be defined in clinical practice as the PSA levels between 10 and 20 ng/mL in accordance with the definition of PSA gray zone.

Various methods, including mpMRI and PSMA PET/CT imaging, have been utilized to enhance the detection rate of PCa by accurately identifying suspicious lesions⁽¹⁹⁾. Technological advancements such as robotic-assisted precise positioning for prostate biopsy have been increasingly explored⁽²⁰⁾. Although these methods can substantially enhance PCa diagnostic efficacy, there is a risk of overdiagnosis in low-risk patients with low PSA, which could result in over-treatment of some patients. Moreover, the expensive costs of their implementation impede their widespread adoption. However, relevant studies have reported that the efficacy of a single systematic or targeted biopsy is surpassed by

Table 6. Comparison of complication rates after biopsy.

	TR-SB (n=128) n (%)	TP-CB (n=115) n (%)	χ^2 -Value	P-Value	OR 95% CI
Fever[cases (%)]	13 (10.1)	4 (3.4)	4.152	0.042	0.99 ~ 9.91
Urinary retention[cases (%)]	6 (4.7)	7 (6.1)	0.234	0.628	0.25 ~ 2.33
Hematuria [cases (%)]	6 (4.7)	6 (5.2)	0.036	0.849	0.28 ~ 2.85
Rectal bleeding [cases (%)]	3 (2.3)	0 (0)	-	0.249 ^a	-
Total [cases (%)]	24 (18.7)	17 (13.6)	0.680	0.410	0.67 ~ 2.63

^aFisher's exact test

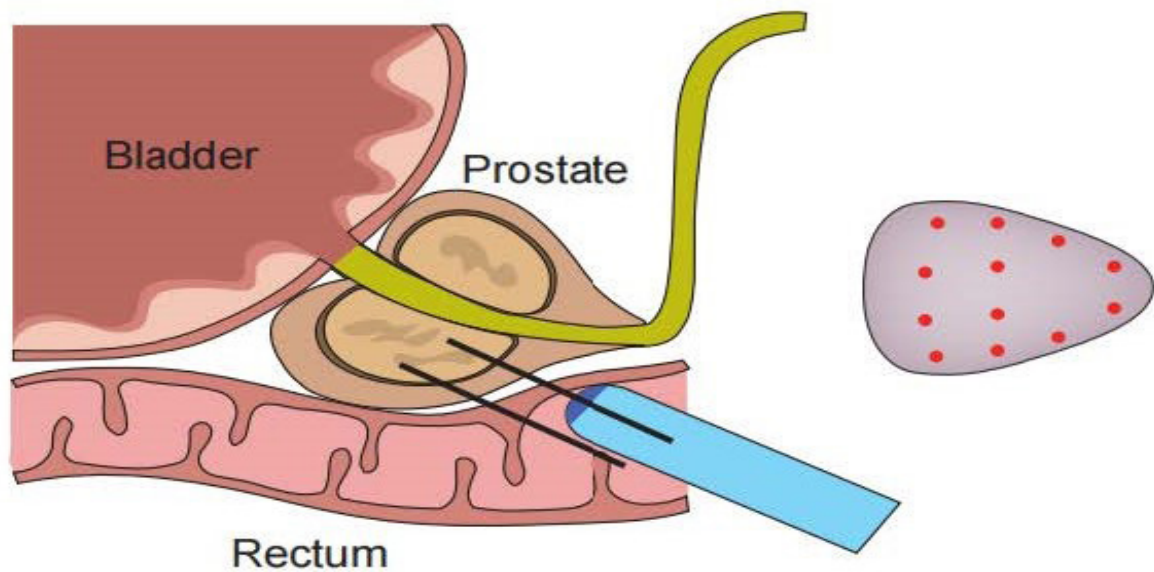


Figure 1. Surgery method of TR-SB.

the efficacy of a systematic combined targeted biopsy in enhancing PCa detection rates, especially CsPCa⁽¹³⁾. Furthermore, the transperineal biopsy route is now preferred over the transrectal route in clinical practice because of its higher PCa detection rate, as the transrectal route may miss certain areas of the prostate⁽¹⁰⁾. Our study compares the diagnostic efficacy of TP-CB and TR-SB in patients with PSA levels of 'sub-gray zone' (10~20 ng/mL) and compares them with patients with PSA levels of 4~10 and 20~40 ng/mL, aiming to provide more accurate diagnostic options for patients with PCa in this PSA zone.

The study demonstrated that the TP-CB group exhibited a higher overall PCa detection rate than the TR-SB group, indicating that TP-CB may have higher diagnostic efficacy. The TP-CB may have a higher detection rate of PCa because of its increased number of puncture

needles. However, further subgroup analysis based on PSA levels revealed no significant difference in PCa and CsPCa detection rates in patients with PSA levels of 4~10 and 20~40 ng/mL. The TP-CB group exhibited higher detection rates for PCa and CsPCa than the TR-SB group in patients with PSA levels of 10~20 ng/mL. Notably, CsPCa detection accounted for a higher proportion of biopsy positives than PCa detection. TP-CB increased the detection rate of PCa, primarily in CsPCa. The enhanced CsPCa detection in patients with PSA of 10~20 ng/mL using TP-CB may have significant clinical implications for clarifying diagnosis, guiding treatment decisions, and improving patient outcomes.

The study results indicated no significant difference in intraoperative blood loss between TP-CB and TR-SB groups, with an average of 0~1 mL. Both procedures are minimally invasive, resulting in negligible bleed-

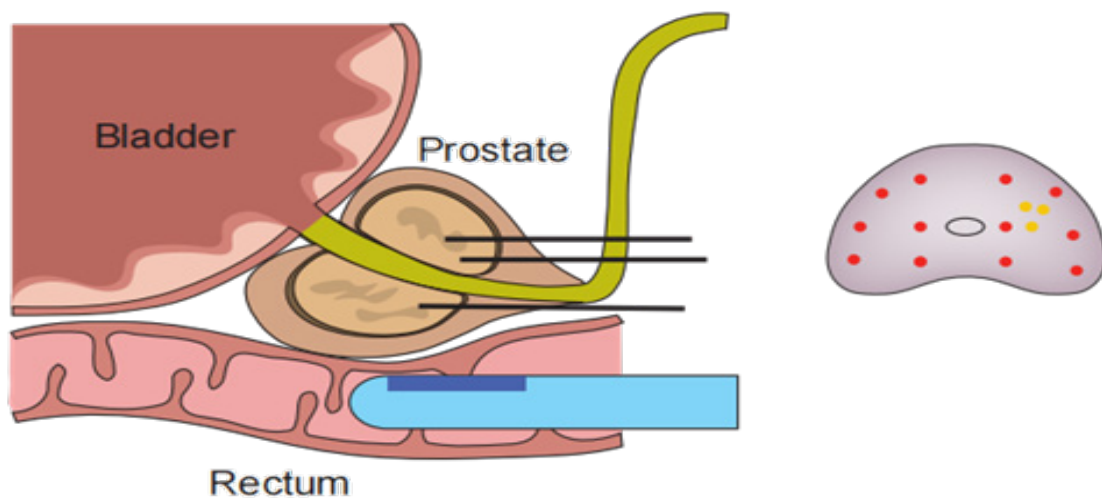


Figure 2. Surgery method of TP-CB.

ing. The TP-CB procedure involves a longer puncture needle tract and more puncture needles than the TR-SB procedure, with the TP-CB site being further from the prostate. The perineum, a more sensitive skin area with abundant innervation, may increase pain levels during biopsy⁽²¹⁾, potentially affecting patient cooperation and prolonging biopsy time. However, despite these differences, there was no significant difference in biopsy time between the TP-CB and TR-SB groups in this study, indicating that TP-CB is a viable option for widespread clinical application.

Additionally, the VAS was employed to assess patients' pain scores during surgery. The average overall VAS scores did not differ significantly when the same analgesic approach, prostatic peripheral nerve block (PPNB), was employed. The study analyzed pain data at different stages of the biopsy procedure, including ultrasound probe insertion, local anesthesia administration, and the actual biopsy. The pain scores for each stage were recorded separately. Results indicated that pain sensitivity was higher in the TP-CB group during PPNB administration; however, there was no significant difference in pain experienced during the biopsy. Overall, transperineal PPNB was more effective in reducing patient discomfort during surgery.

This complication is an essential indicator for evaluating the safety of the procedure. The rectum harbors a higher concentration of bacteria than the perineum. These bacteria can enter the bloodstream or prostate tissue through a biopsy needle, thereby increasing the risk of complications, including bacterial infection and sepsis⁽²²⁻²⁴⁾. The safety profiles of the TP-CB and TR-SB groups were similar in this study, as there was no significant difference in the overall incidence of complications. Despite the potential higher risk of bleeding and infection associated with more puncture needles in TP-CB, postoperative febrile infections were significantly lower in TP-CB than in TR-SB. TP-CB was more efficacious in preventing postoperative febrile infections. Most patients experienced mild visible hematuria after the biopsy, which typically did not require any specific treatment. Hematuria is primarily due to urethral injury during surgery, which results in bleeding. The transperineal route allows for more precise needle placement parallel to the urethra, reducing the risk of injury and resulting in milder bleeding reactions⁽²⁵⁾.

The number of cases in this study is a limitation; however, further validation, improvement, and enhancement are required through larger sample sizes and more extended research periods.

CONCLUSIONS

In conclusion, the detection rate of PCa in patients with PSA gray zones and those with PSA levels of 20–40 ng/mL was non-significant between the two methods. However, we demonstrated that TP-CB is more efficacious than TR-SB in enhancing PCa detection in patients with PSA of 10–20 ng/mL, particularly in CsPCa. Although the two methods did not exhibit a substantial difference in overall complication rates, TP-CB exhibited a lower incidence of postoperative febrile infections, indicating a better safety profile. TP-CB demonstrates higher diagnostic and clinical utility for patients in the PSA 'sub-gray zone' and is more suitable for widespread clinical use.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

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