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Research Progress on Concurrent Surgical Approaches in the Treatment of Benign Prostatic Hyperplasia (BPH)

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Abstract: Benign prostatic hyperplasia (BPH) is an age-related non-cancerous condition, affecting approximately 50% of men over the age of 50, with the prevalence rising to over 80% in men over 80 years old. Elevated prostate-specific antigen (PSA) levels are commonly indicative of prostate diseases such as BPH or prostate cancer. In patients with multiple comorbidities and a limited life expectancy, even if prostate cancer is diagnosed, they may not be candidates for radical surgery. Therefore, a treatment approach that can both diagnose and relieve lower urinary tract obstruction is needed. Performing prostate biopsy and surgical treatment concurrently allows for both diagnosis and therapy in a single procedure, reducing the risks and recovery time associated with multiple surgeries, while enhancing the patient's treatment experience and satisfaction. This article aims to explore the efficacy and safety of concurrent prostate biopsy and 1470 nm laser surgery.

Keywords: Benign Prostatic Hyperplasia; Prostate Biopsy; 1470 nm Laser Surgery; Concurrent Surgery.

1. Introduction

The diagnosis of Benign Prostatic Hyperplasia (BPH) relies on a comprehensive approach that includes medical history, physical examination, laboratory tests, and imaging assessments[1]. The International Prostate Symptom Score (IPSS) is used to evaluate the severity of symptoms, while the Quality of Life (QOL) score assesses the impact on daily life. Digital rectal examination (DRE) is performed to evaluate prostate size, and prostate-specific antigen (PSA) testing is used to assess the risk of prostate cancer and the progression of BPH. If necessary, transrectal ultrasound (TRUS) and urodynamic studies are conducted to assess prostate volume and urinary flow obstruction. Patients with mild symptoms can be managed with lifestyle modifications and regular follow-up, while those with moderate to severe symptoms may require pharmacological treatments such as alpha-blockers and 5-alpha reductase inhibitors. For patients with severe symptoms or those unresponsive to medications, laser surgery or transurethral resection of the prostate (TURP) can be considered. Among these, 1470 nm laser surgery is favored due to its minimal trauma and fast recovery. Performing prostate biopsy and 1470 nm laser surgery concurrently allows for the simultaneous exclusion of prostate cancer and relief of urinary obstruction, thus reducing the risks associated with multiple surgeries. This method reduces anesthesia-related risks, shortens hospital stays, improves patient quality of life, reduces psychological stress, and lowers medical costs, making it especially suitable for elderly and multi-morbid patients. Overall, it represents an efficient, safe, and cost-effective treatment option that optimizes patient experience and alleviates symptoms.

2. Prostate Biopsy

2.1. Indications for Prostate Biopsy

The indications for initial prostate biopsy [2] include the following: The presence of a suspicious nodule detected on digital rectal examination (DRE); Detection of suspicious lesions on transrectal ultrasound (TRUS), prostate MRI, or CT imaging;

Serum total prostate-specific antigen (tPSA) levels exceeding 10 μg/L;In cases where serum tPSA is in the range of 4–10 μg/L, a free-to-total prostate-specific antigen ratio (f/t PSA) lower than 0.16, and/or prostate-specific antigen density (PSAD) higher than 0.15, and/or prostate-specific antigen velocity (PSAV) greater than 0.75 μg/ (L·year); Abnormal findings from other tumor markers, such as positive urine prostate cancer antigen 3 (PCA3);Evidence suggesting metastatic prostate cancer.

2.2. Approaches to Prostate Biopsy

According to the European Association of Urology (EAU) guidelines for prostate cancer, the most accurate method for diagnosing prostate cancer (PCa) is prostate biopsy, which is primarily performed via two approaches: transperineal (TP) and transrectal (TR) routes [2]. TP biopsy is generally performed in the lithotomy position, with sampling guided by ultrasound after iodine tincture disinfection, usually collecting 12 cores. TR biopsy is commonly performed in the left lateral decubitus position, with an ultrasound probe inserted through the anus, and typically involves 8 to 12 core samples. A retrospective analysis by Xiang et al. [3] of 3,278 prostate biopsy cases showed that both methods had similar cancer detection rates, and there were no significant differences in the incidence of complications such as acute urinary retention and hematuria ($P>0.05$). The perineal approach was not associated with complications like rectal bleeding or fever but resulted in more patient discomfort. A meta-analysis by Pradere et al. [4] of 16,941 cases indicated that the transperineal approach reduced the risk of rectal bleeding and infection. Due to the higher rates of sepsis and mortality associated with TR biopsy, the UK has implemented the "TRexit" initiative, replacing TR with TP and recommending its global adoption [5].

2.3. Number of Biopsy Cores

In 1989, Hodge et al. [6] first proposed the use of a 6-core

systematic biopsy method to diagnose prostate cancer (PCa), which quickly became the standard practice. Subsequently, many researchers suggested that increasing the number of biopsy cores could reduce the risk of missed diagnoses and improve the positive detection rate. For example, Yang Lingbo et al. [7] conducted a retrospective analysis of 126 suspected PCa patients using 6-core, 10-core, and 12-core biopsy methods. The results showed positive detection rates of 42.9%, 58.8%, and 62.0%, respectively. As research progressed, the number of biopsy cores gradually increased, from the initial 8, 10, and 12 cores to 14 cores, eventually evolving into the saturation biopsy technique with more than 22 cores [8]. However, studies have also shown that the increase in the positive detection rate becomes limited after 10 cores. A study by Chen Xin et al. [9] involving 90 patients found no significant difference in the positive detection rate between the 10-core and 13-core methods (38% vs. 40%, respectively). Additionally, Hwang et al. [10] compared biopsies using different volumes of prostate silicone models and pointed out that the positive detection rate is closely related to prostate volume. Therefore, they recommended that the number of biopsy cores should be determined based on prostate size.

2.4. The Role of Magnetic Resonance Imaging (MRI) in Prostate Biopsy

Hricak et al. first explored the clinical application of MRI in the diagnosis of prostate diseases in 1983. Compared to CT and PET, MRI is less influenced by the pelvic structure and provides a more accurate depiction of the prostate's anatomical features. The primary sequences recommended for diagnosis [11] include T1-weighted imaging (T1WI), T2-weighted imaging (T2WI), diffusion-weighted imaging (DWI), and dynamic contrast-enhanced magnetic resonance imaging (DCE). On T2WI, prostate cancer (PCa) typically appears as a hypointense lesion in the peripheral zone, and its imaging performance is superior to that of other imaging techniques [12].

2.5. MRI/TRUS Cognitive Fusion Targeted Prostate Biopsy

MRI offers unique advantages in the diagnosis of prostate cancer, but its high cost and operational complexity present notable drawbacks. In contrast, although transrectal ultrasound (TRUS) has lower diagnostic accuracy than MRI, particularly in detecting lesions in the transition zone and central zone, it is portable, easy to use, and more cost-effective. By combining MRI with TRUS, a more cost-efficient diagnostic approach can be achieved, with ultrasound-guided biopsies of suspicious lesions identified on MRI. The cognitive fusion method requires the operator to accurately identify three-dimensional target lesions constructed from MRI within the TRUS image, which places higher demands on the operator's experience and skill. A study by Park et al. [13] demonstrated that the cancer detection rate using multiparametric MRI (mpMRI)-guided targeted biopsy can reach 30%, significantly higher than the 10% rate for TRUS. Haffner et al. [14] also validated the advantage of MRI-targeted biopsy in improving detection rates. Although this technique has lower equipment requirements, the operator must overcome challenges in image matching through extensive practice, particularly when dealing with large prostates or small lesions. When choosing a targeted biopsy technique, both the operator's experience and equipment costs should be carefully considered.

2.6. Summary

According to the Expert Consensus on Prostate Biopsy [2], prostate biopsy is considered the gold standard for diagnosing suspected prostate cancer in patients with elevated PSA levels, particularly in the gray zone of PSA levels ranging from 4 to 10 ng/mL. Additionally, the cognitive fusion technique combining MRI with ultrasound significantly enhances the accuracy of targeted biopsies. Compared to transrectal biopsy, the transperineal approach carries a lower risk of infection and bleeding, making it particularly suitable for sampling complex lesions [15].

3. The Fundamentals and Principles of Laser and Surgical Treatment

3.1. Holmium Laser

The holmium laser (2140 nm) has strong water absorption properties, with a penetration depth of less than 0.4 mm, thus limiting thermal damage to the surrounding prostate tissue. Its pulse duration is shorter than the thermal conduction time of tissue, providing excellent hemostatic effects. Additionally, physiological saline can be used for irrigation during the procedure [16]. Since the 1990s, the holmium laser has been widely applied in the treatment of benign prostatic hyperplasia (BPH). Common surgical techniques include Holmium Laser Ablation of the Prostate (HoLAP), Holmium Laser Resection of the Prostate (HoLRP), and Holmium Laser Enucleation of the Prostate (HoLEP). Among these, HoLAP involves vaporizing tissue using high temperatures, HoLRP first fragments prostate tissue before removal, while HoLEP directly enucleates the hyperplastic tissue, crushes it, and removes it. HoLEP typically results in shorter operative times compared to HoLRP.

3.2. Thulium Laser

In 2003, the first-generation thulium laser system was introduced, with a power output of approximately 50 W. Subsequently, the second and third-generation systems launched in 2007 and 2009, respectively, further increased the laser power, significantly improving resection efficiency, shortening operation times, and reducing the incidence of complications [17]. Currently, commonly used thulium laser devices include YAG lasers, thulium-fiber lasers, and Cyber thulium lasers, all of which operate at a wavelength of approximately 2 μm. Thulium lasers offer several advantages over other types of lasers, including efficient cutting ability, matching absorption peaks with water, shallow penetration depth, and clear visualization.

3.3. Green Laser

Green laser (wavelength 532 nm) is a continuous, non-contact laser with strong absorption by hemoglobin, but weaker absorption by water, thus providing excellent vaporization effects. Its penetration depth is approximately 0.8 mm, allowing for the formation of a coagulation layer 1 to 2 mm deep within the tissue. This enables effective resection of prostate tissue while reducing the risk of postoperative edema and necrosis [18].

3.4. Semiconductor Laser

Semiconductor lasers are generated through semiconductor diodes and resonant cavities, offering a wide range of output

wavelengths. Common wavelengths used for the treatment of benign prostatic hyperplasia (BPH) include 940 nm, 980 nm, and 1470 nm. Among these, the 1470 nm wavelength laser is particularly effective due to its ability to be absorbed by both water and hemoglobin, providing superior tissue vaporization and hemostatic effects [19]. Jiang Donggen et al. [20] employed the 1470 nm laser in a retrograde surgical approach to treat BPH patients. The results showed an average surgical time of 65 ± 14 minutes, an average indwelling catheter time of 4.5 ± 1.5 days, and significant improvements in IPSS and QOL one month post-surgery, with no adverse reactions. Yin Zhengkun et al. [21] compared the clinical outcomes of transurethral prostate resection (TURP) and 1470 nm laser vaporization for BPH treatment. The results indicated that the 1470 nm laser vaporization had less trauma, faster postoperative recovery, and better treatment outcomes with good safety. This laser technology allows for precise cutting of prostate tissue and effective hemostasis, making it a promising new laser treatment for BPH.

3.5. Comparison of Different Laser Surgical Techniques

Currently, laser technology is widely used in the treatment of benign prostatic hyperplasia (BPH), with common types including holmium laser, thulium laser, green laser, and semiconductor laser [22]. Compared to traditional transurethral resection of the prostate (TURP), these laser techniques offer distinct advantages. Holmium laser (2140 nm) has a penetration depth of 0.5 mm, primarily used for short-pulse excitation, where energy is mainly absorbed by water. However, it is associated with a higher incidence of postoperative complications such as urinary incontinence and urethral stricture, and has a steeper learning curve. Thulium laser (wavelength approximately 2 μm) has a penetration depth of 6-27 mm, allowing for rapid removal of small tissue fragments, but it is often accompanied by edema and inflammatory responses, resulting in longer postoperative recovery time. Green laser (532 nm) offers excellent hemostatic effects with a penetration depth of about 0.8 mm, but it has a higher incidence of secondary surgeries. The 1470 nm semiconductor laser, being absorbed by both water and hemoglobin, provides superior hemostasis. Compared to holmium laser, it offers better postoperative outcomes; compared to thulium laser, it effectively reduces postoperative lower urinary tract symptoms and shortens catheterization and hospitalization times. Additionally, the semiconductor laser has a higher vaporization efficiency than green laser. Moreover, it has a shorter learning curve, making the procedure relatively simpler and yielding more ideal results.

3.6. Summary

The 1470 nm laser surgery demonstrates significant advantages in the treatment of benign prostatic hyperplasia (BPH), exhibiting excellent cutting and coagulation abilities. Due to its minimal intraoperative bleeding, it is particularly suitable for patients at high risk of bleeding or those on anticoagulant therapy [23]. This technique results in less tissue trauma, rapid postoperative recovery, and allows patients to return to normal activities more quickly, with reduced postoperative pain and discomfort, as well as a significantly shorter hospital stay. Compared to traditional transurethral resection of the prostate (TURP), the 1470 nm laser surgery shows superior efficacy and safety, reducing blood loss, lowering the incidence of postoperative complications such as urinary incontinence and electrolyte imbalances, and significantly shortening the duration of catheter retention and hospitalization [24]. In conclusion, prostate biopsy plays a key role in determining the cause of elevated PSA levels and excluding malignant lesions, while 1470 nm laser surgery provides a safe and effective minimally invasive solution for the diagnosis and treatment of BPH by precisely vaporizing and removing hyperplastic tissue, effectively relieving urinary obstruction. With its advantages of minimal bleeding and fast recovery, it offers a safe, efficient approach to BPH treatment.

4. The Impact of Puncture on Laser Surgery

The study by Xue Xiyun[25] indicates that for patients with a history of prostate biopsy, HoLEP surgery is a safe and effective treatment option. Compared to patients without a history of biopsy, there were no significant differences in terms of surgical time, intraoperative bleeding, catheterization time, or bladder irrigation time. Additionally, there were no notable changes in postoperative complications or treatment outcomes. The study by Jia Yijie[26] explored the safety and efficacy of performing HoLEP surgery shortly (within 5-7 days) after transperineal prostate biopsy. The findings suggest that although performing HoLEP surgery within 5 to 7 days after biopsy may increase the duration of the surgery and blood loss ($P<0.05$), it does not significantly affect liver and kidney function, electrolyte balance, symptom improvement, quality of life, or the incidence of complications ($P>0.05$). Currently, there is limited research on performing 1470 nm laser surgery immediately following prostate biopsy, and issues such as intraoperative bleeding and surgical difficulty still require further investigation.

5. Clinical Demand and Safety Analysis of Simultaneous Surgery

Simultaneous prostate biopsy and 1470 nm laser surgery offer significant clinical value for elderly patients with multiple comorbidities who are not candidates for radical surgery and present with elevated PSA levels. This combined approach allows both diagnosis and treatment in a single procedure, making it particularly suitable for patients suspected of having prostate cancer along with urinary tract obstruction. The excellent hemostatic properties of the 1470 nm laser help reduce intraoperative and postoperative bleeding risks, while any bleeding caused by the biopsy can be managed with preoperative anticoagulation strategies and meticulous monitoring. Strict aseptic techniques and prophylactic antibiotic use help minimize the risk of infection, ensuring surgical safety. The high level of precision required and the flexibility in scheduling demand that the medical team possess extensive experience and excellent collaboration, ultimately improving surgical success rates and postoperative recovery. This highlights the integrated diagnostic and therapeutic benefits of this approach.

6. Discussion

6.1. Advantages of Simultaneous Surgery

The simultaneous performance of prostate biopsy and 1470 nm laser surgery offers the advantage of seamlessly integrating diagnosis and treatment, allowing patients to

undergo both procedures in a single operation. This approach reduces the risks associated with multiple surgeries and anesthesia, thereby enhancing overall safety and patient comfort. Additionally, it shortens hospitalization and recovery times, saving medical resources and costs, while enabling patients to return to their daily lives more quickly. Furthermore, this treatment minimizes the need for multiple hospital admissions and nursing care, reducing healthcare expenditures, and alleviating the psychological stress between diagnosis and treatment. This, in turn, improves patient compliance and satisfaction, particularly for those with chronic or multiple health conditions. Overall, this innovative approach improves treatment efficiency and reflects advancements in modern medicine, particularly in terms of integrated diagnosis and treatment and the efficient use of healthcare resources.

6.2. Potential Limitations

Although simultaneous surgery offers clear advantages in terms of time-saving and cost reduction, its operational complexity places higher demands on the surgical team, particularly in patients with a high risk of malignancy. Preoperative assessments must be thorough, and postoperative monitoring should be comprehensive to address any potential complications. If cancer is confirmed after the biopsy, further treatment strategies must be reevaluated to ensure that the patient receives the optimal therapeutic approach.

6.3. Comparison with Other Treatment Methods

Compared to traditional transurethral resection of the prostate (TURP) and pharmacological treatments, 1470 nm laser surgery demonstrates significant advantages in terms of minimally invasive nature, reduced bleeding, faster recovery, and shortened hospital stays. In terms of safety and efficacy, laser surgery has a lower postoperative complication rate, especially in patients with large prostates. Compared to long-term pharmacological treatments, laser surgery provides more durable symptom relief and reduces dependence on long-term medication. However, current research on combined procedures is still limited, and therefore, large-scale multicenter studies are essential to validate their long-term efficacy and broader applicability.

References

[1] Shen, X. (2018). Ethnic differences in prostate enlargement-related indicators among Han, Hui, and Tibetan populations in Qinghai (Master's thesis, Qinghai University).

[2] Fu, Q., Han, B., Liu, Z., & Ge, J. (2022). Expert consensus on prostate biopsy. Chinese Journal of Andrology, 28(5), 462–470.

[3] Xiang, J., Yan, H., Li, J., Wang, X., Chen, H., & Zheng, X. (2019). Transperineal versus transrectal prostate biopsy in the diagnosis of prostate cancer: a systematic review and meta-analysis. World journal of surgical oncology, 17(1), 31.

[4] Pradere, B., Veeratterapillay, R., Dimitropoulos, K., Yuan, Y., Omar, M. I., MacLennan, S., Cai, T., Bruyère, F., Bartoletti, R., Köves, B., Wagenlehner, F., Bonkat, G., & Pilatz, A. (2021). Nonantibiotic Strategies for the Prevention of Infectious Complications following Prostate Biopsy: A Systematic Review and Meta-Analysis. The Journal of urology, 205(3), 653–663.

[5] Grummet, J., Gorin, M. A., Popert, R., O'Brien, T., Lamb, A. D., Hadaschik, B., Radtke, J. P., Wagenlehner, F., Baco, E., Moore, C. M., Emberton, M., George, A. K., Davis, J. W., Szabo, R. J., Buckley, R., Loblaw, A., Allaway, M., Kastner, C., Briers, E., Royce, P. L., … Woo, H. H. (2020). "TREXIT 2020": why the time to abandon transrectal prostate biopsy starts now. Prostate cancer and prostatic diseases, 23(1), 62–65.

[6] Hodge, K. K., McNeal, J. E., Terris, M. K., & Stamey, T. A. (1989). Random systematic versus directed ultrasound guided transrectal core biopsies of the prostate. The Journal of urology, 142(1), 71–75.

[7] Yang, L. B., Wang, P. S., Li, F. P., Wang, Y. B., & Hou, Y. C. (2015). Comparison of the 6-needle, 10-needle, and 12-needle methods for ultrasound-guided transrectal prostate biopsy in the diagnosis of prostate cancer. Chinese Journal of Geriatrics, 06, 1578-1580.

[8] Wu, W. W., Lü, C., & Liu, Z. X. (2020). Comparison of diagnostic efficacy and complications of 16G and 18G needles for ultrasound-guided transrectal prostate biopsy in the diagnosis of prostate cancer. Chinese Journal of Andrology, 01, 31-35.

[9] Chen, X., Li, W., & Liu, J. L. (2013). Clinical comparison of 5-zone 13-core and 4-zone 10-core prostate biopsy for diagnosing prostate cancer. Journal of Modern Integrated Traditional Chinese and Western Medicine, 24, 2653-2654.

[10] Hwang, S. I., & Lee, H. J. (2019). Comparison of the diagnostic yield of various systematic randomized prostate biopsy protocols using prostate phantoms made of devil's tongue jelly. Ultrasonography (Seoul, Korea), 38(1), 44–49.

[11] Qian, G. Q., Xu, Q. Z., & Qian, Y. F. (2024). Diagnostic value of biomarkers combined with mp-MRI quantitative parameters for prostate cancer. Chinese Journal of Gerontology, 21, 5169-5172.

[12] Engels, R. R., Israël, B., Padhani, A. R., & Barentsz, J. O. (2020). Multiparametric magnetic resonance imaging for the detection of clinically significant prostate cancer: what urologists need to know. Part 1: acquisition. European urology, 77(4), 457-468.

[13] Park, B. K., Park, J. W., Park, S. Y., Kim, C. K., Lee, H. M., Jeon, S. S., Seo, S. I., Jeong, B. C., & Choi, H. Y. (2011). Prospective evaluation of 3-T MRI performed before initial transrectal ultrasound-guided prostate biopsy in patients with high prostate-specific antigen and no previous biopsy. AJR. American journal of roentgenology, 197(5), W876–W881.

[14] Haffner, J., Lemaitre, L., Puech, P., Haber, G. P., Leroy, X., Jones, J. S., & Villers, A. (2011). Role of magnetic resonance imaging before initial biopsy: comparison of magnetic resonance imaging-targeted and systematic biopsy for significant prostate cancer detection. BJU international, 108(8 Pt 2), E171–E178.

[15] Chen, Y. C., Liu, H. Q., Liu, Y. Q., Wang, J. W., & Tao, L. S. (2024). Application value of artificial intelligence-magnetic resonance imaging geometric model in transperineal prostate targeted biopsy. Journal of Urological Surgery (Electronic Edition), 03, 49-53.

[16] Elshal, A. M., El-Assmy, A., Mekkawy, R., Taha, D. E., El-Nahas, A. R., Laymon, M., El-Kappany, H., & Ibrahiem, E. H. (2017). Prospective controlled assessment of men's sexual function changes following Holmium laser enucleation of the prostate for treatment of benign prostate hyperplasia. International urology and nephrology, 49(10), 1741–1749.

[17] Yang, G. S., Chen, B. T., & Li, H. H. (2017). Application, innovation, and optimization of laser treatment for benign prostatic hyperplasia in China. Journal of Clinical Urology, 04, 245-249.

[18] Ye, P., & Cheng, F. (2019). Advances in minimally invasive treatment for benign prostatic hyperplasia. Medical Review, 05, 957-962.

[19] Wang, Y., Jia, Z., & Xu, Y. (2023). Laser treatment of benign prostatic hyperplasia. Chinese Journal of Clinical Doctors, 09, 1022-1024.

[20] Jiang, D., Xiao, C., Pang, J., Zhang, H., Mao, Y., & Gao, X. (2017). 1470 nm laser enucleation of the prostate for the treatment of benign prostatic hyperplasia. Chinese Journal of Laparoscopic Urology, Electronic Edition, 01, 4-8.

[21] Yin, Z., & Liu, Y. (2019). Transurethral resection of the prostate versus 1470 nm semiconductor laser vaporization for the treatment of benign prostatic hyperplasia. Chinese Journal of Sexual Science, 03, 25-28.

[22] Yu, M., & Tian, Z. (2019). Clinical research progress on laser treatment of benign prostatic hyperplasia. China Urban and Rural Enterprise Health, 07, 89-92.

[23] Chai, S. (2021). Efficacy analysis of transurethral prostate column water balloon dilation versus prostate resection in the treatment of small volume benign prostatic hyperplasia (Master's thesis, North China University of Science and Technology).

[24] Liu, J., Mao, C., Li, J., & Guan, X. (2022). Efficacy analysis of 1470 nm laser selective prostate adenoma enucleation in the treatment of BPH patients.

[25] Xue, X., Huang, J., & Zhao, Y. (2020). Efficacy analysis of transurethral holmium laser enucleation for BPH patients with a history of prostate biopsy.

[26] Jia, Y., Zhou, G., & Liu, C. (2023). Impact of transperineal prostate biopsy on the safety and efficacy of HoLEP performed in the short term.