RESEARCH ARTICLE

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Comparative Analysis of Three Surgical Instruments in the Treatment of High Critical Enucleation of Prostate

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Abstract

Objective: We conducted a study to assess the effectiveness and safety of three different surgical instruments for enucleation in treating high-risk benign prostatic hyperplasia (BPH). These instruments include red laser, green laser, and plasma surgical equipment for enucleation of the prostate. **Method:** In a retrospective analysis, 237 patients diagnosed with high-risk benign prostatic hyperplasia (BPH) underwent prostate enucleation using three different groups of surgical instruments at the Department of Urology, the First Affiliated Hospital of Jinzhou Medical University. These groups included the red laser device group (n = 67), the green laser device group (n = 61), and the plasma device group (n = 109). The study evaluated changes in prostate mass, blood loss, operation time, and postoperative efficacy at 1- and 6-month intervals, as well as any associated complications. **Results:** The red and green laser surgical instrument groups demonstrated superiority over the plasma group in several aspects. (1) Operation Time: *1* Red laser group: 87.9 ± 14.7 minutes; *1* Green laser group: 86.1 ± 15.3 minutes. (2) Blood Loss: *1* Red laser group: 30.1 ± 5.9 mL; *2*Green laser group: 30.9 ± 6.1 mL. (3) Temporary Urinary Incontinence: *1*Red laser group: 3 cases (4.48%); *2*Green laser group: 2 cases (3.28%). These differences were statistically significant. Additionally, postoperative indicators such as IPSS(International Prostate Prostate Symptom Score), QoL(Quality of Life), Q max(The Maximum Flow Rate), and RUV(Residual Urine Volume) showed significant improvement in all three groups compared to the preoperative state. **Conclusion:** Red laser, green laser and plasma surgical devices were safe and effective in the treatment of high critical benign prostatic hyperplasia; laser surgical devices showed better performance in terms of operation time, intraoperative bleeding and complications.

Keywords: High critical benign prostatic hyperplasia- Red laser- Green laser- Plasma- Enucleation

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Introduction

Benign prostatic hyperplasia (BPH) is one of the most common diseases in urology, the incidence is 30%-50%. Because there are many elderly patients, it is often associated with a variety of diseases. Our definition is high-risk BPH: prostate mass > 50 g, age > 70 years, combined with two or more serious lesions of vital organs and impaired function. Because of its high surgical risk, conservative treatment or conservative surgical options (cystostomy) are often performed in clinical practice, which often have poor results and low satisfaction rates. In China, Professor Liu Chunxiao pioneered transurethral prostate enucleation, which has been widely promoted in China and has become a routine standard operation [1]. According to reports, the effect is accurate and stable, and the safety of skilled operators is considered better than TURP in the academic field. At present, the clinical application of various endoluminal surgical instruments for enucleation surgery has been reported [2]. However, the application of that kind of equipment for enucleation surgery is more effective, less recommended in clinical practice, and often depends on the limitations of objective instruments in hospitals and the operating habits of surgeons. Therefore, under the premise of skilled operation of surgical instruments, there is a lack of data guidance for selecting that kind of device for clinical application. At present, our hospital has three kinds of surgical instruments including red laser, green laser and plasma, and the same surgeon can skillfully apply three groups of surgical instruments for prostate enucleation. To summarize and analyze the clinical effect of enucleation of prostate using these three different surgical instruments, compare the differences in the preoperative and postoperative effects of IPSS, Qmax, PVR, QOL and other indicators, as well as the differences in the quality of resected prostate, intraoperative blood loss, operation time, etc., providing more clinical data reference for the selection of surgical instruments for the clinical treatment of high-risk benign prostatic hyperplasia, and the planning of the plan [1, 2].

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Materials and Methods

Study subjects: Specific inclusion criteria and exclusion criteria. Inclusion criteria Meet high critical BPH criteria and prostate surgery indications: high critical BPH criteria: (1) prostate mass > 50 g; (2) patients aged > 70 years; (3) organ function damage, vital organ serious lesions 2 or more (such as hypertension, diabetes, chronic renal insufficiency, coronary heart disease, cerebral hemorrhage, chronic bronchitis, cerebral infarction, installation of cardiac pacemakers, preoperative risk assessment of heart disease: according to ASA classification [2].

Indications for BPH surgery: (1) urinary retention with bladder stones; (2) secondary upper urinary tract hydrops caused by urinary retention (with or without renal impairment); (3) recurrent urinary tract infections; (4) long-term oral drug conservative treatment is not effective, 5a-reductase inhibitors are ineffective; (5) at least one extubation can not urinate or two urinary retention; (6) BPH patients with inguinal hernia, hemorrhoids, rectocele, large bladder diverticulum and other clinical judgment of lower urinary tract obstruction is difficult to achieve.

Exclusion criteria were: (1) those who could not understand the questionnaire correctly; (2) urethral stricture; (3) confirmed neurogenic bladder; (4) bladder neck contracture; (5) elevated PSA, and needle biopsy results suggestive of prostate cancer; and (6) unsuccessful follow-up.

A total of 237 patients were finally enrolled, including 67 patients who underwent surgery in the red laser surgical device group, 61 patients who underwent surgery in the green laser surgical device group, and 109 patients who underwent surgery in the plasma device group. Complications: (1) bladder stones: 7 cases in red laser group, 6 cases in green laser group and 6 cases in plasma group; (2) urinary retention: 10 cases, 11 cases and 14 cases in 3 groups, respectively; (3) bladder diverticulum: 8 cases, 10 cases and 9 cases in 3 groups, respectively; (4) secondary upper urinary tract hydrops: 4 cases, 5 cases and 10 cases in 3 groups, respectively. The differences among the three groups had no statistical significance ($P > 0.05$)

Study design

Retrospective analysis of patients with high critical benign prostatic hyperplasia hospitalized in the Department of Urology, the First Affiliated Hospital of Jinzhou Medical University from September 2019 to October 2023 who underwent prostate enucleation using three surgical instruments: red laser, green laser, and plasma. It is specifically divided into two parts: preoperative treatment and surgical treatment.

Preoperative treatment

(1) hypertension: < 160/90 mmHg; (2) diabetes: fasting blood glucose < 9 mmol/L; (3) acute cardiovascular and cerebrovascular diseases: myocardial infarction, cerebral hemorrhage, cerebral infarction stable condition > 6 months; (4) cardiac insufficiency: cardiology consultation evaluation > grade 2; (5) respiratory diseases: after preoperative consultation medication, pulmonary heart disease, emphysema, chronic bronchitis and other pulmonary insufficiency stable condition after surgery; (6) obstructive chronic renal insufficiency: indwelling urinary catheter, renal urea nitrogen, creatinine recovery close to normal after surgery.

Surgical treatment was performed using lithotomy position and combined spinal-epidural block anesthesia, and antibiotics were intravenously infused 1 day before surgery to prevent infection. Specific application equipment is as follows: Red laser surgical equipment: Spanish LNTERMEDIC ARFRAN S. A. Input (Inpul), 220- 240 VAC/50 Hz/700 VA. Output 100/60 W. Green laser surgical equipment: Beijing Ruiltong Laser Technology Co., Ltd. Nd: YAG/LBO green laser surgical system PVP-160, input power 4.4kw, output 90Wo plasma surgical equipment: Gyrus Plasma Vaporization System 30 ° endoscope, imager, monitor, electrotome cutter, isotonic flushing fluid, UK. Power 200/100w tissue morcellator: medical surgical shaver manufactured by Hangzhou Haoke Photoelectric Instrument Co., Ltd., setting rotation number 3 ~ 5, manual adjustment of suction pressure, input power 100 VA.

Surgical methods

According to the anatomical curve [3], enter the bladder along the urethra, and view the position of important landmarks such as verumontanum, external urethral sphincter, bladder neck, and bilateral ureteral orifices in turn. Check whether there is blood spurting, bladder stones and tumors in bilateral ureteral orifices. A point incision was performed from the urethral mucosa in the anterior verumoniculi, and the potential space between the surgical envelope prostates was quickly identified with the retrograde thrust knife electrotomy. The middle lobe and lateral lobe of the hyperplasia prostate gland were separated by the three-leaf method, and hemostasis was paid attention to. Finally, the connected mucosal cord tissue was cut off, the prostate was pushed into the bladder, and the prostate tissue was crushed by EILK flusher out. A 22 Fr or 24 Fr triple lumen catheter was indwelled and irrigated with isotonic irrigation fluid. Bladder irrigation was performed until clear in patients with red urine after surgery. Outcome measures: blood loss, quality of prostatectomy, operation time, complications; follow-up QoL, Qmax, RUV indicators 1 month, 3 months, 6 months improvement; IIEF5(International Index of Erectile Function Questionnaire-5) score 1 month, 6 months changes.

Statistical methods SPSS 20. 0 software was used for statistical analysis. The P values in the analysis of variance results were used to determine whether there were significant differences in the operation time, resection time of different prostate weights, blood loss and resection gland quality among the three surgical devices for prostate enucleation; the P values in Fisher's exact probability method in the chi-square test were used to determine whether there were random correlations in the number of capsular perforations, bladder ruptures, temporary urinary incontinence and bladder neck contractures among the three surgeries, with $P < 0.05$ considered statistically significant.

Results

There was no significant difference in preoperative index data and general conditions among red laser device group, green laser device group and plasma device group, with comparability.

Operation time

(87.9 ± 14.7) min, (86.1 ± 15.3) min and (124.8 ± 19.5) min in red laser device group, green laser device group and plasma device group, respectively. The operation time in plasma group was significantly prolonged, and the difference had statistical significance (P < 0.05) (Table 1).

Resection time of different prostate weights

the operation time of prostate mass greater than 80 g in red laser device group (87.9 ± 14.7) min was 76.51% higher than that of 50-80 g (49.8 ± 5.7) min; the operation time greater than 80 g in green laser device group (88. 6 ± 5.2) min was 74.41% higher than that of 50-80 g (50.8 ± 5.1) min; the operation time greater than 80 g in plasma device group (134.6 ± 9.7) min was 96. 21% higher than that of 50-80 g (68. 6 ± 6.9) min. According to the results of one-way ANOVA, there was no significant difference between the red laser group and the green laser group (P>0.05) (F(2,234)=1.330, p=0.360; F(2,234)=3.800, p=0.089). The difference in plasma group was statistically significant (p<0.05) (F(2,234)=6.790, P=0.037), as shown in Table 2.

Bleeding volume

The bleeding volume of red laser instrument group, green laser instrument group and plasma instrument group was (30.1±5.9) mL, (30.9±6.1) mL and (60.3 ± 9.6) mL, respectively. According to the results of one-way ANOVA, there was no significant difference between the red laser group and the green laser group (P>0.05) (F(2,234)=1.290, p=0.390; F(2,234)=2.680, p=0.210). The difference in plasma group was statistically significant (p<0.05) (F(2,234)=7.150, P=0.029) (Table 3).

Mass of resected gland

The mass of resected gland in red laser device group, green laser device group and plasma device group was (54.9 ± 6.1) g, (57.2 ± 6.6) g and (57.9 ± 5.2) g, respectively, and there was no significant difference among the three groups (P > 0.05), as shown in Table 4.

Number of capsule perforations

The number of capsule perforations in the red, green laser and plasma device groups was 2 (2.99%), 3 (4.92%) and 5 (4.59%), respectively, and there was no significant difference between the groups (P > 0.05), as shown in Table 4.

Number of bladder rupture

The number of bladder rupture in the red, green laser and plasma device groups was 2 cases (2.99%), 2 cases (3.28%) and 5 cases (4.59%), respectively, and there was no significant difference between the groups (P > 0.05), as shown in Table 4.

Number of temporary urinary incontinence

The number of cases of temporary urinary incontinence in the red and green laser groups and plasma device groups was 3 (4.48%), 2 (3.28%) and 15 (13. 76%), respectively. The plasma device group was significantly higher than the red and green laser groups, and the difference had statistical significance (P < 0.05). See Table 4.

Number of bladder neck contracture

No bladder neck contracture occurred in the red and green laser device groups, and 2 cases (3.2%) of bladder neck contracture occurred in the plasma device, with no significant difference between the groups (P > 0.05).

Postoperative follow-up

Qmax, RUV, IPSS, QoL and other indicators were

Table 1. Preoperative General Conditions of Patients in the Tthree Groups

Group	n	Age	Prostate mass (g)	PSA (ng / mL)	Qmax (mL / s)	RUV (mL)	Qol	IPSS
RedLaser Group	67	78. 3± 5. 2	85. 9± 29. 7	3. 54± 0. 85	9. 40± 2. 91	156. 6±39. 6	3. 9± 0. 7	21. 9± 5. 0
GreenLaser	61	77. 6± 5. 4	81. 4± 30. 8	3. 63± 0. 81	9. 49± 3. 62	154. 8±37. 9	4. 0± 0. 8	21. 3± 5. 1
Plasma	109	78. 1± 4. 9	81. 8± 31. 6	3. 71± 0. 79	9. 36± 3. 78	150. 1±40. 1	4. 2± 0. 5	21. 8± 4. 9

Table 2. Analysis of Variance Results of Prostate Surgery time with Different Masses

Stable	Sum of squares		Degrees of freedom	Mean square	F	P
RedLaser	Intergroup	0.64	2	0.32	1.33	0.36
	Within Group	56.16	234	0.24		
	Total	56.8	236			
GreenLaser	Intergroup	1.14	2	0.57	3.8	0.089
	Within Group	35.1	234	0.15		
	Total	36.24	236			
Plasma	Intergroup	3.26	2	1.63	6.79	0.037
	Within	56.16	234	0.24		
	Total	59.42	236			

Table 3. Bleeding Volume Aanalysis of Variance Results

Stable	Sum of squares		Degrees of freedom	Mean square	F	P
RedLaser	Intergroup	0.72	2	0.36	1.29	0.39
	Within	65.52	234	0.28		
	Total	66.24	236			
GreenLaser	Intergroup	1.02	2	0.51	2.68	0.21
	Within	44.46	234	0.19		
	Total	45.48	236			
Plasma	Intergroup	1.86	2	0.93	7.15	0.029
	Within	30.42	234	0.13		
	Total	32.28	236			

Table 4. Significant Results of Fisher-Freeman-Halton Exact Probability Test for Mass of Resected Gland and Number of Capsular Perforations (Bilateral)

Stable	Excised gland mass	Capsular perforation	Bladder rupture	Transient incontinence	Bladder neck contracture
Red Laser Group X Green Laser Group	0. 71	0. 66	0. 52	0. 05	0. 34
Green Laser Group X Plasma Group	0. 36	0. 41	0. 53	0. 03	0. 16
Red Laser Group X Plasma Group	0. 62	0. 35	0. 57	0. 02	0. 30

significantly improved at 1 month and 6 months after postoperative follow-up compared with those before operation, and the differences had statistical significance ($P < 0.05$). There was no significant difference in various indicators at 1 month and 6 months among the three groups ($P > 0.05$). No urethral stricture occurred during the follow-up period in each group. See Table 5

Discussion

Red laser, green laser and plasma equipment were satisfactory in the treatment of high-risk benign prostatic hyperplasia, and there was no significant difference in the quality of resected glands among the three groups, indicating that the three surgical equipment and "enucleation" surgical methods could achieve satisfactory resection quality. IPSS, QoL, Qmax, RUV and other indicators of each group were significantly improved after 1 and 6 months of follow-up compared with those before surgery, indicating that the three devices can achieve the exact effect in the "enucleation" treatment of high-risk prostate cancer. However, there were differences in bleeding volume, operation time, and temporary urinary incontinence. The blood loss in the plasma device group was significantly more than that in the red and green laser groups, which was related to the more exact laser hemostasis and clearer vision, and was also related to the technical characteristics of plasma enucleation. Domestic reports mostly show that plasma enucleation technology has less bleeding, but compared with laser equipment, plasma enucleation surgery still has relatively more bleeding [1]. First, the blood supply is blocked first, and then the gland is removed. During the blocking process, multiple points of repeated hemostasis are carried out,

Table 5. Relevant Scores before Operation and at 1 and 6 Mmonths after Operation

Stable	IPSS	QoL	IIEF5	Q max (ml / s)	RUV (mL)
Red Laser Group					
Before surgery	22. 0±4. 7	3. 9± 0. 6	14. 4± 6. 0	9. 41±2. 3	156. 8±26. 4
1 month post-op	7. 8± 2. 3*	2. 4±0. 6*		25. 23±7. 03*	20. 24±6. 58*
6 months post-op	7. 6± 2. 1*	2. 3±0. 5*	16. 6±4. 2*	26. 35±6. 35*	19. 22±6. 59*
Green Laser Group					
Before surgery	21. 4±3. 2	4. 0± 0. 6	14. 8± 5. 8	9. 52±2. 51	155. 6±31. 2
1 month post-op	7. 6± 1. 9*	2. 3±0. 7*		26. 26±6. 64*	19. 67±7. 36*
6 months post-op	7. 5± 1. 9*	2. 2±0. 6*	16. 2±5.3*	27. 87±6. 86*	18. 99±7. 29*
Plasma Group					
Before surgery	21. 4±3. 6	4. 1± 0. 5	15. 5± 6. 9	9. 37±3. 88	149. 3±37. 7
1 month post-op	7. 6± 2. 8*	2. 8±0. 8*		19. 97±8. 28*	22. 01±6. 1*
6 months post-op	7. 8± 2. 2*	2. 6±0. 7*	16. 4±6. 1*	22. 31±9. 22*	19. 62±5. 6*

Notes: IPSS, International Prostate Symptom Score; QoL, Quality of Life Score; IIEF5, International Index of Erectile Function Questionnaire-5; Q max, The Maximum Flow Rate; RUV, Residual Urine Volume.

which makes the hemostasis time longer. It can also lead to increased surgical bleeding. We also found that plasma enucleation did not extend the operation time much in the large prostate group, and plasma enucleation had its own advantages in the larger glands. The reason is considered to be small prostate hyperplasia most combined with prostatitis, the surgical envelope is not very clear, the enucleation process is time-consuming, not easy to enucleate, easy to cause the envelope perforation, and higher requirements for the operator. "It is necessary to enucleate and the envelope cannot be perforated", and some cases may even change to TURP resection, so saving time is limited. There was no significant difference in the capsule perforation rate between the red and green laser groups and the plasma group. The plasma itself had the function of protecting the capsule. The possibility of cutting through the surgical capsule was also very small in this surgical procedure itself, while the red and green laser had a lower capsule perforation rate because of its exact hemostasis, bright vision, and more exact hemostasis under the premise of uncertain capsule. Causing capsule perforation, mainly due to intraoperative misoperation, long pedal, laser local long time cutting, resulting in capsule perforation. The plasma device group had more temporary urinary incontinence after operation than the red and green laser device groups, considering that the external sphincter was implicated and squeezed during the "reverse push" process of transurethral sheath enucleation, resulting in temporary injury. No urethral stricture was found in the follow-up at 1 and 6 months after surgery in the three groups. Therefore, in the application of "enucleation" surgery, the three surgical instruments of red and green laser groups and plasma group were effective in the treatment of high critical BPH, and the resection of glandular tissue was equivalent, but the plasma device group was slightly inferior to the plasma device group in terms of operation time, blood loss, and temporary urinary incontinence complications. At the same time, we found that in clinical practice, the operation proficiency of each device is significantly related, and different surgeons cannot compare under the premise of inconsistent operation proficiency of various devices, which varies greatly. However, under the premise of the same surgeon and skilled application equipment, red and green laser surgical equipment has more advantages than plasma equipment.

In China with an aging population, benign prostatic hyperplasia (BPH) is a common disease in urology, in which BPH patients with multiple complications are the main body of treatment [4]. There is no uniform standard for the definition of severe high-risk BPH [5]. In this report, we report that BPH patients aged > 70 years with two or more serious lesions of vital organs and impaired function, prostate mass > 50g, meeting the above three items belong to the category of high-risk BPH. Although TURP, which was introduced in 1925, is still the "gold standard" for surgical treatment of BPH internationally. However, TURP is a "minimally invasive" procedure and not a "minor" procedure, and long-term clinical practice has also found more complications associated with TURP surgery [6]. Blood transfusion, dysuria, urinary tract infection, transurethral resection syndrome [7]. For patients with high critical BPH, due to its high surgical risk, complications caused by TURP are not uncommon, and even transferred to ICU for further treatment, resulting in high critical BPH in some hospitals "dare not be operated", most of them underwent conservative treatment methods such as conservative surgery (suprapubic cystostomy) and conservative treatment (long-term indwelling catheter), resulting in low satisfaction, poor effect, low quality of life, and nursing difficulties [8], so the surgical methods that can make patients and their families satisfied, and the surgical methods for high critical BPH with high quality of life are still in the exploration, attempt, and summary stage. With technological innovation, a variety of minimally invasive endoluminal surgical instruments have been applied in the field of endoscopic prostatic surgery, resulting in a continuous decrease in the overall rate of minimally invasive prostatic surgery by TURP [9], from 81.00% in 1999 to 39% in 2005 [10]. Gyrus, UK, introduced a dynamic plasma kinetic resectoscope using bipolar circuit [11], which has the effects of cutting, vaporization and electrocoagulation. On this basis, Professor Liu Chunxiao in China independently innovated the "transurethral plasmakinetic enucleation of the prostate" using the characteristics of the "enucleation" technique of open prostate surgery and the application of plasmakinetic resectoscope [12]. Some domestic scholars have found that prostate enucleation has great advantages over TURP in improving the maximum urinary flow rate, postoperative extubation time, intraoperative complications, and postoperative complication follow-up [13]. In recent years, laser technology has been widely used in the field of prostate surgery. "Laser enucleation of prostate is also widely used and popularized in some large and medium hospitals and some primary hospitals. The therapeutic effect is exact, and the safety and effectiveness of laser enucleation in the treatment of BPH are further confirmed. Zhang Junfeng et al also reported thulium laser was safe in the treatment of high-risk and critically ill patients with benign prostatic hyperplasia [3].This is associated with more definitive laser hemostasis and clearer vision [14]. In summary, red and green lasers and plasma surgical instruments can achieve better therapeutic effects in patients with high-risk BPH [15], but red and green lasers are more effective in the application of prostate enucleation under the premise that the same surgeon and surgical instruments are skilled.

Author Contribution Statement

All authors contributed equally in this study.

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