Comparison of Emergency Room Visits and Rehospitalization for Bleeding Complications following Transurethral Procedures for the Treatment of Benign Prostatic Hyperplasia: A Population-Based Retrospective Cohort Study

Shih-Liang Chen 1, Chih-Kai Hsu 1, Chun-Hsiang Wang 2,3, Che-Jui Yang 4,†, Ting-Jui Chang 1, Yu-Hsuan Chuang 1,† and Yuan-Tsung Tseng 5,*

1 Department of Urology, Tainan Municipal Hospital (Managed by Show Chwan Medical Care Corporation), Tainan City 701, Taiwan
2 Department of Hepatogastroenterology, Tainan Municipal Hospital (Managed by Show Chwan Medical Care Corporation), Tainan City 701, Taiwan
3 Department of Optometry, Chung Hwa Medical University, Tainan City 717, Taiwan
4 Department of Urology, Chang Bing Show Chwan Memorial Hospital, Changhua 505, Taiwan
5 Department of Medical Research, Tainan Municipal Hospital (Managed by Show Chwan Medical Care Corporation), Tainan City 701, Taiwan
* Correspondence: 2a0074@tmh.org.tw; Tel.: +886-6-2609926
† These authors contributed equally to this work.

Abstract: Background: The postoperative bleeding complications associated with laser surgery of the prostate and transurethral resection of the prostate (TURP) were compared. Methods: We used the Taiwan National Health Insurance Research Database to conduct an observational population-based cohort study. All eligible patients who received transurethral procedures between January 2015 and September 2018 were enrolled. Patients who received laser surgery or TURP were matched at a ratio of 1:1 by using propensity score matching, and the association of these procedures with bleeding events was evaluated. Results: A total of 3302 patients who underwent elective transurethral procedures were included. The multivariable Cox regression analysis revealed that diode laser enucleation of the prostate (DiLEP) resulted in significantly higher emergency room risks within 90 days after surgery due to clot retention than the Monopolar transurethral resection of the prostate (M-TURP) (Hazard Ratio: 1.52; 95% Confidence Interval [CI], 1.06–2.16, \( p = 0.022 \)). Moreover, GreenLight photovaporization of the prostate (PVP) (0.61; 95% CI, 0.38–1.00 \( p = 0.050 \)) and thulium laser vaporization of the prostate (ThuVARP) (0.67; 95% CI, 0.47–0.95, \( p = 0.024 \)) resulted in significantly fewer rehospitalization due to clot retention than did M-TURP. No significant increase in blood clots were observed in patients using comedications and those with different demographic characteristics and comorbidities. Conclusions: Among the investigated six transurethral procedures for Benign prostatic hyperplasia, PVP and ThuVARP were safer than M-TURP because bleeding events and clot retention were less likely to occur, even in patients receiving anticoagulant or antiplatelet therapy. However, DiLEP and holmium laser enucleation of the prostate (HoLEP) did not result in fewer bleeding events than M-TURP.

Keywords: benign prostatic obstruction; transurethral resection of the prostate; laser surgery of the prostate; clot retention

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M-TURP is associated with short-term postoperative bleeding-related complications such as hematuria and clot retention [2]. Bipolar TURP (B-TURP) is a safe and effective procedure with a significantly shorter operating time and efficacy similar to that of conventional M-TURP [3].

The introduction of TURP was followed by the advent of laser technology, which led to the development of therapies with greater efficacy and fewer complications than TURP. GreenLight photovaporization of the prostate (PVP), thulium laser vaporesection of the prostate (ThuVARP), holmium laser enucleation of the prostate (HoLEP), and diode laser (980 nm) enucleation of the prostate (DiLEP) are more efficient laser techniques compared to TURP, with reported reproducible clinical results and few bleeding-related complications [4–6].

Because of the increasing prevalence of comorbidities and indications, the number of patients with BPH undergoing transurethral laser procedures increased. Transurethral laser procedures are associated with lower intraoperative blood loss and fewer discharge days [7–9]. However, no definite conclusions were drawn because of insufficient evidence. Moreover, few studies compared severe bleeding tendencies associated with all transurethral laser procedures and TURP in the same baseline population. This study evaluated the postoperative bleeding complications among common laser techniques and TURP for BPH.

2. Materials and Methods

2.1. Data Sources

The National Health Insurance Research Database (NHIRD) is a population-level dataset derived from the claims data of more than 99% of people in Taiwan enrolled in the NHI program [10]. The research database includes data on patients’ medical history, medication use, surgical intervention history, personal data, and diagnosis identified on the basis of the International Classification of Diseases, Ninth and Ten Revision, Clinical Modification (ICD-9-CM and ICD-10-CM, respectively) diagnosis codes [11,12].

The study protocol was approved by the Research Ethics Committee of Show Chwan Memorial Hospital (IRB-No: 1091213), and the requirement for informed consent was waived because the NHIRD datasets contain no identifiable personal information.

2.2. Study Design

We conducted a nationwide cohort study by retrieving NHIRD data on hospitalized patients who underwent their first TURP or laser surgery between 2015 and 2018. Follow-up data before enrollment were used to evaluate comorbidities. The discharge date of patients after surgery was considered their index date.

In order to evaluate the postoperative status of patients, we performed a follow-up for 15, 30, 60, and 90 days after surgery and calculated the occurrence of emergency room (ER) visits and rehospitalizations during the postsurgical period. Furthermore, we determined the statistical differences between these rates according to patient characteristics and surgery type.

2.3. Surgery Types

The M-TURP uses a single active electrode at the surgery site with a non-conductive hypo-osmolar irrigation medium. The B-TURP incorporates monopolar technology and is performed in a normal saline environment, addressing the dilutional hyponatremia of conventional monopolar TURP [13,14].

Type of laser techniques includes PVP, ThuVARP, HoLEP, and DiLEP. Based on the different wavelength-dependent laser–prostatic tissue interactions, the main techniques are coagulation, vaporization, resection, and enucleation. Although each laser type is different in design, their principle is not distinctive [15,16].
Patients underwent either TURP (M-TURP or B-TURP) or transurethral laser procedures, namely PVP, ThuVARP, HoLEP, and DiLEP. The flowchart of patient selection and inclusion and exclusion criteria are provided in Figure 1.

**Figure 1.** Flowchart of patient selection. Abbreviations: TURP: transurethral resection of the prostate; M-TURP: monopolar transurethral resection of the prostate; B-TURP: bipolar transurethral resection of the prostate; CCI: Charlson comorbidity index; HCD: hypertensive cardiovascular disease; DM: diabetes mellitus; CKD: chronic kidney disease.

### 2.4. Covariate Assessment

We identified the following covariates that are potential confounders: Charlson comorbidity index (CCI), age, and medication history. The medication history of the following drugs was assessed: statins, angiotensin-converting enzyme inhibitors (ACEIs), β-blockers, anticoagulant drugs (warfarin, rivaroxaban, apixaban, dabigatran etexilate, enoxaparin, tirofiban, heparin, and fondaparinux), antiplatelet drugs (aspirin, cilostazol,
clopidogrel, dipyridamole, prasugrel, rivaroxaban, and ticlopidine), spironolactone, and 5-α-reductase inhibitors.

We also assessed the following comorbidities: diabetes mellitus (DM; ICD-9 CM code 250 and ICD-10 CM codes E10.0, E10.1, E10.9, E11.0, E11.1, and E11.9), hypertensive cardiovascular disease (HCD; ICD-9 CM codes 401–405 and ICD-10 CM codes I10–I15), chronic kidney disease (CKD; ICD-9 CM code 585 and ICD-10 CM code N18), hyperlipidemia (ICD-9 CM code 272 and ICD-10 CM code E78), heart failure (ICD-9 CM code 428 and ICD-10 CM code I50), bladder cancer (ICD-9 CM code 188 and ICD-10 CM code C67), and prostate cancer (ICD-9 CM code 185 and ICD-10 CM code C61).

2.5. Main Outcome Measurements

2.5.1. Postoperative Bleeding Complications Leading to ER Visits

We evaluated the bleeding events leading to ER visits in patients with urine retention, acute urine retention, hematuria, using tranexamic acid, and who underwent diagnostic or treatment procedures, including bladder sonography, bladder instillation, bladder irrigation with a foley catheter, or bladder blood clot evacuation with a Toomey bladder evacuator.

2.5.2. Postoperative Bleeding Complications Leading to Rehospitalization

We evaluated the bleeding events leading to rehospitalization in patients using tranexamic acid and who underwent diagnostic or treatment procedures, including bladder sonography or cystoscopy (the inspection of the bladder and urethra with cystoscopy and removal of clots with suction), bladder blood clot evacuation with a Toomey bladder evacuator, bladder instillation, and intermittent or continuous bladder irrigation with a foley catheter.

2.6. Statistical Methods

We performed between-group comparisons by using the paired \( t \)-test [17] for continuous variables and McNemar’s [18] test for categorical variables. Cox regression [19] analysis with covariates was used to estimate the relationship and differences in the risk of bleeding between the TURP and laser surgery groups. The hazard ratios (HRs) and 95% confidence intervals (CIs) for the outcomes were measured for all groups. The Kaplan–Meier method was used to estimate the outcomes of the study cohorts. The differences between the curves were examined using the log-rank test [20].

Propensity Score Matching

Propensity score matching (PSM) is a popular approach for estimating treatment effects by using observational data [21]. In order to reduce selection bias and the effects of confounders, we used robust PSM to create matched sets of patients who underwent TURP and those who underwent laser surgery at a ratio of 1:1 with full matching without replacement. Logistic regression was used for propensity score calculation [22]; the covariates used in the logistic regression model were age, DM, HCD, CKD, hyperlipidemia, CCI, and the index year at the start of the follow-up. The flowchart of surgery type and matching is presented in Figure 1.

Baseline characteristics were matched using PSM to reduce potential selection bias. PSM was performed using multivariate logistic regression, and matching was performed using the package of R Statistical Software “MatchIt” (version 4.4.0; R Core Team 2021, Vienna, Austria). Statistical analysis was performed using SPSS 21.0 (SPSS Inc., Chicago, IL, USA), and statistical significance was set at \( p < 0.05 \).

3. Results

3.1. Patient Characteristics

Patients with noncancerous BPH who underwent surgery between 2015 and 2018 were included in this study (Figure 1). We performed PSM and included 3302 patients; of them, 1651 underwent laser surgery, and 1651 underwent B-TURP or M-TURP. The mean age
and CCI of patients were 70.9 ± 8.4 years and 3.2 ± 2.6. The demographic characteristics of the TURP group and laser surgery groups are listed in Table 1. Patients in both groups were men with similar age and comorbidity distributions. No differences in common event-related comorbidities and medication history were observed between the groups.

Table 1. Baseline characteristics of patients who underwent laser surgery or TURP.

| Age, year (mean ± SD) | Laser | % | TURP | % | p |
|-----------------------|-------|---|------|---|---|
| 50–59                 | 70.9 ± 8.4 | 145 | 70.9 ± 8.4 | 145 | 1.000 |
| 60–69                 | 36.6 | 605 | 36.6 | 605 | 1.000 |
| 70–79                 | 36.0 | 594 | 36.0 | 594 | 1.000 |
| >80                   | 18.6 | 307 | 18.6 | 307 | 1.000 |
| CCI (mean ± SD)       | 3.2 ± 2.6 | 1.000 |
| CCI 0                 | 15.6 | 258 | 15.6 | 258 | 1.000 |
| 1–2                   | 31.1 | 513 | 31.1 | 513 | 1.000 |
| 3–4                   | 24.0 | 397 | 24.0 | 397 | 1.000 |
| >4                    | 29.3 | 483 | 29.3 | 483 | 1.000 |
| DM                    | 70.4 | 1162 | 70.4 | 1162 | 1.000 |
| Y                     | 29.6 | 489 | 29.6 | 489 | 1.000 |
| HCD                   | 32.8 | 542 | 32.8 | 542 | 1.000 |
| Y                     | 67.2 | 1109 | 67.2 | 1109 | 1.000 |
| CKD                   | 89.1 | 1471 | 89.1 | 1471 | 1.000 |
| Y                     | 10.9 | 180 | 10.9 | 180 | 1.000 |
| Hyperlipidemia        | 48.0 | 793 | 48.0 | 793 | 1.000 |
| Y                     | 52.0 | 858 | 52.0 | 858 | 1.000 |
| Heart failure         | 64.6 | 1066 | 64.6 | 1086 | 0.465 |
| Y                     | 35.4 | 585 | 35.4 | 565 | 0.342 |
| Statins               | 61.1 | 1008 | 61.1 | 1029 | 0.452 |
| Y                     | 38.9 | 643 | 38.9 | 622 | 0.377 |
| ACEI                  | 51.8 | 856 | 51.8 | 856 | 1.000 |
| Y                     | 48.2 | 795 | 48.2 | 795 | 0.517 |
| β-blocker             | 38.0 | 628 | 38.0 | 645 | 0.543 |
| Y                     | 62.0 | 1023 | 62.0 | 1006 | 0.543 |
| Anticoagulant         | 92.5 | 1527 | 92.5 | 1506 | 0.182 |
| Y                     | 7.5 | 124 | 7.5 | 145 | 8.8 |
| Antiplatelet          | 44.6 | 736 | 44.6 | 755 | 0.506 |
| Y                     | 55.4 | 915 | 55.4 | 896 | 0.543 |
| Spirinolactone        | 90.3 | 1491 | 90.3 | 1476 | 0.387 |
| Y                     | 9.7 | 160 | 9.7 | 175 | 10.6 |
| 5α reductase inhibitors | 60.1 | 992 | 60.1 | 1043 | 0.068 |
| Y                     | 39.9 | 659 | 39.9 | 608 | 36.8 |

Abbreviations: CCI, Charlson comorbidity index; HCD, hypertensive cardiovascular disease; DM, diabetes mellitus; CKD, chronic kidney disease; ACEI, angiotensin-converting enzyme inhibitor.

Table 2 presents the results of further subgroup analysis to investigate the baseline differences among the M-TURP, B-TURP, PVP, ThuVARP, HoLEP, and DiLEP groups (Table 2). No differences in common comorbidities and medication history were observed among the six groups.

3.2. Comparison of the Length of Hospital Stay among Different Surgery Types

Patients were stratified into six subgroups, and the groups were balanced using PSM. Significantly fewer inpatient days were observed in the PVP (3.9 ± 2.5 days, p < 0.001), ThuVARP (3.9 ± 2.7 days, p < 0.001), HoLEP (4.1 ± 1.3 days, p = 0.663), DiLEP (4.0 ± 1.9 days, p = 0.002), and B-TURP (4.5 ± 3.8 days, p = 0.283) groups than in the M-TURP (4.9 ± 4.3 days) group (Figure 2).
Table 2. Baseline characteristics of patients who underwent different LEPs or TURPs.

| M-TURP | % | PVP | % | DiLEP | % | HoLEP | % | ThuVARP | % | B-TURP | % | p |
|--------|---|-----|---|-------|---|------|---|--------|---|-------|---|---|
| Age 50–59 | 100 | 9.9 | 8.1 | 28 | 9.9 | 5 | 10.9 | 81 | 8.6 | 45 | 7.1 | 0.854 |
| 60–69 | 355 | 35 | 136 | 35.4 | 112 | 39.7 | 16 | 34.8 | 341 | 36.3 | 250 | 39.2 |
| 70–79 | 367 | 36.2 | 138 | 35.9 | 94 | 33.3 | 17 | 37 | 345 | 36.7 | 227 | 35.6 |
| >80 | 192 | 18.9 | 79 | 20.6 | 48 | 17 | 8 | 17.4 | 172 | 18.3 | 115 | 18.1 | 0.898 |
| CCI 0 | 147 | 14.5 | 54 | 14.1 | 42 | 14.9 | 7 | 15.2 | 155 | 16.5 | 111 | 17.4 |
| 1–2 | 325 | 32.1 | 119 | 31 | 80 | 28.4 | 12 | 26.1 | 302 | 32.2 | 188 | 29.5 |
| 3–4 | 239 | 23.6 | 92 | 24 | 76 | 27 | 13 | 28.3 | 216 | 23 | 158 | 24.8 |
| >4 | 303 | 29.9 | 119 | 31 | 84 | 29.8 | 14 | 30.4 | 266 | 28.3 | 180 | 28.3 |
| DM N | 705 | 69.5 | 269 | 70.1 | 197 | 69.9 | 28 | 60.9 | 668 | 71.1 | 457 | 71.7 | 0.664 |
| Y | 309 | 30.5 | 115 | 29.9 | 85 | 30.1 | 18 | 39.1 | 271 | 28.9 | 180 | 28.3 |
| HCD N | 330 | 32.5 | 122 | 31.8 | 98 | 34.8 | 13 | 28.3 | 309 | 32.9 | 212 | 33.3 | 0.945 |
| Y | 684 | 67.5 | 262 | 68.2 | 184 | 65.2 | 33 | 71.7 | 630 | 67.1 | 425 | 66.7 |
| CKD N | 900 | 88.8 | 341 | 88.8 | 253 | 89.7 | 37 | 80.4 | 840 | 89.5 | 571 | 89.6 | 0.53 |
| Y | 114 | 11.2 | 43 | 11.2 | 29 | 10.3 | 9 | 19.6 | 99 | 10.5 | 66 | 10.4 |
| Hyperlipidemia N | 485 | 47.8 | 189 | 49.2 | 133 | 47.2 | 15 | 32.6 | 456 | 48.6 | 308 | 48.4 | 0.436 |
| Y | 529 | 52.2 | 195 | 50.8 | 149 | 52.8 | 31 | 67.4 | 483 | 51.4 | 329 | 51.6 |
| Heart failure N | 674 | 66.5 | 246 | 64.1 | 182 | 64.5 | 30 | 65.2 | 608 | 64.7 | 412 | 64.7 | 0.949 |
| Y | 340 | 33.5 | 138 | 35.9 | 100 | 35.5 | 16 | 34.8 | 331 | 35.3 | 225 | 35.3 |
| Statins N | 624 | 61.5 | 232 | 60.4 | 181 | 64.2 | 23 | 50 | 572 | 60.9 | 405 | 63.6 | 0.431 |
| Y | 390 | 38.5 | 152 | 39.6 | 101 | 35.8 | 23 | 50 | 367 | 39.1 | 232 | 36.4 |
| ACEI N | 536 | 52.9 | 179 | 46.6 | 150 | 53.2 | 21 | 45.7 | 506 | 53.9 | 320 | 50.2 | 0.17 |
| Y | 478 | 47.1 | 205 | 53.4 | 132 | 46.8 | 25 | 54.3 | 433 | 46.1 | 317 | 49.8 |
| β-blocker N | 378 | 37.3 | 156 | 40.6 | 91 | 32.3 | 18 | 39.1 | 363 | 38.7 | 267 | 41.9 | 0.104 |
| Y | 636 | 62.7 | 228 | 59.4 | 191 | 67.7 | 28 | 60.9 | 576 | 61.3 | 370 | 58.1 |
| Anticoagulant N | 923 | 91 | 340 | 88.5 | 263 | 93.3 | N/A | 880 | 93.7 | 583 | 91.5 | 0.027 |
| Y | 91 | 9 | 44 | 11.5 | 19 | 6.7 | N/A | 59 | 6.3 | 54 | 8.5 |
| Antiplatelet N | 448 | 44.2 | 161 | 41.9 | 122 | 43.3 | 18 | 39.1 | 435 | 46.3 | 307 | 48.2 | 0.308 |
| Y | 566 | 55.8 | 223 | 58.1 | 160 | 56.7 | 28 | 60.9 | 504 | 53.7 | 330 | 51.8 |
| Spironolactone N | 902 | 89 | 348 | 90.6 | 256 | 90.8 | 43 | 93.5 | 844 | 89.9 | 574 | 90.3 | 0.832 |
| Y | 112 | 11 | 36 | 9.4 | 26 | 9.2 | 3 | 6.5 | 95 | 10.1 | 63 | 9.9 |
| 5α reductase inhibitor N | 655 | 64.6 | 244 | 63.5 | 162 | 57.4 | 27 | 58.7 | 559 | 59.5 | 388 | 60.9 | 0.13 |
| Y | 359 | 35.4 | 140 | 36.5 | 120 | 42.6 | 19 | 41.3 | 380 | 40.5 | 249 | 39.1 |

1 N/A: Number of bleeding events in the HoLEP group was <3. According to the data protection policy of NHIRD, data less than 3 cannot be provided. Abbreviations: CCI, Charlson comorbidity index; HCD, hypertensive cardiovascular disease; DM, diabetes mellitus; CKD, chronic kidney disease; ACEI, angiotensin-converting enzyme inhibitor.

Figure 2. Average length of hospital stay following TURP and laser surgery. ** p < 0.01, and *** p < 0.001 versus M-TURP. 1 M-TURP was the reference group.
3.3. Comparison of ER Visits with Rehospitalization Due to Postoperative Bleeding

We estimated the proportion of patients who returned to our ER due to clot retention within 15, 30, 60, and 90 days after surgery (Table 3).

The percentage of patients who returned to our ER due to bleeding events within 90 days after surgery was the highest in the HoLEP group (17.4%, \( p = 0.104 \)), followed by the DiLEP (15.2%, \( p = 0.026 \)), B-TURP (10.5%, \( p = 0.934 \)), PVP (9.6%, \( p = 0.387 \)), ThuVARP (9.4%, \( p = 0.257 \)), and M-TURP (10.4%, reference) groups.

The percentage of patients who were rehospitalized for bleeding events within 90 days after surgery was the highest in the DiLEP group (8.9%, \( p = 0.714 \)), followed by the M-TURP (8.1%, reference), B-TURP (6.0%, \( p = 0.119 \)), PVP (5.2%, \( p = 0.039 \)), and ThuVARP (N/A, \( p = 0.277 \)) groups.

3.4. Effect of Surgery Type on Bleeding Events

The effect of six surgeries on the risk of bleeding events was assessed using the multivariate Cox regression analysis with adjustment for age, sex, CCI, comediations (statins, ACEIs, \( \beta \)-blockers, anticoagulants, antiplatelets, spironolactone, and 5-\( \alpha \)-reductase inhibitors), comorbidities (HCD, hyperlipidemia, DM, and CKD), and the index year at the start of follow-up.

We evaluated the bleeding events leading to ER visits within 90 days after surgery. The adjusted HRs of the PVP (0.92; 95% CI, 0.63–1.34, \( p = 0.677 \)) and ThuVARP (0.91; 95% CI, 0.68–1.20, \( p = 0.493 \)) groups were lower than that of the M-TURP group; however, the difference was nonsignificant. The HRs of DiLEP (1.52; 95% CI, 1.06–2.16, \( p = 0.022 \)), HoLEP (1.70; 95% CI, 0.83–3.50, \( p = 0.150 \)), and B-TURP (1.04; 95% CI, 0.76–1.41, \( p = 0.826 \)) groups were higher than that of the M-TURP group (Table 4).

The analysis of the bleeding visits leading to rehospitalization within 90 days after surgery revealed that the adjusted HRs of the PVP (0.61; 95% CI, 0.38–1.00 \( p = 0.050 \)) and ThuVARP (0.67; 95% CI, 0.47–0.95, \( p = 0.024 \)) groups were significantly lower than that of the M-TURP group. Moreover, the HR of the DiLEP (1.12; 95% CI, 0.71–1.75, \( p = 0.634 \)) group was higher than that of the M-TURP group (Table 5).

Regarding bleeding events leading to ER visits, the 90-day cumulative incidence following laser surgery was not significantly different from that of TURP (\( p = 0.796 \); Figure 3A), and the same was verified between PVP, ThuVARP, and B-TURP and M-TURP. Moreover, the bleeding risk following HoLEP and DiLEP was higher than after M-TURP (\( p = 0.050 \), \( p = 0.708 \); Figure 3B).

Regarding the bleeding events leading to rehospitalization, the 90-day cumulative incidence post-laser surgery was not significantly different after TURP (\( p = 0.145 \); Figure 4A). The cumulative incidence of bleeding events leading to rehospitalization was lower in the PVP and ThuVARP groups than that of the M-TURP cohort (\( p = 0.026 \), \( p = 0.069 \); Figure 4B).

3.5. Comparison of Postoperative Bleeding between the Subgroups of Demographics, Comorbidities, and Comedications

Significantly higher rates of clot retention leading to rehospitalization were noted in patients aged >80 years (2.93; 95% CI, 1.52–5.65, \( p = 0.001 \)). A high CCI score (>4) was observed in patients visiting the ER due to bleeding events after 90 days of surgery (2.36; 95% CI, 1.43–3.92, \( p = 0.001 \)). No significant differences in bleeding events were observed between patients visiting the ER and those who were rehospitalized in the subgroups of comorbidities (DM, HCD, CKD, hyperlipidemia, and heart failure) and comediations (statins, ACEIs, \( \beta \)-blockers, anticoagulants, antiplatelets, spironolactone, and 5-\( \alpha \)-reductase inhibitors).
Table 3. Postoperative bleeding events in patients who underwent different LEPs or TURPs.

|                | M-TURP 1 (%) | PVP (%) | DiLEP (%) | HoLEP 2 (%) | ThuVARP (%) | B-TURP (%) |
|----------------|--------------|---------|-----------|-------------|-------------|------------|
|                | (n = 1014)   | (n = 384) | (n = 282) | (n = 46)    | (n = 939)   | (n = 637)  |
| **Emergency room** |              |         |           |             |             |            |
| 15 days        | 68 6.7       | 28 7.3  | 33 11.7   | 5 10.9      | 60 6.4      | 44 6.9     |
|                |              |         |           |             |             |            |
| 30 days        | 86 8.5       | 30 7.8  | 37 13.1   | 6 13        | 72 7.7      | 51 8       |
|                |              |         |           |             |             |            |
| 60 days        | 98 9.7       | 35 9.1  | 43 15.2   | 8 17.4      | 83 8.8      | 65 10.2    |
|                |              |         |           |             |             |            |
| 90 days        | 105 10.4     | 37 9.6  | 43 15.2   | 8 17.4      | 88 9.4      | 67 10.5    |
| **Rehospitalization** |              |         |           |             |             |            |
| 15 days        | 23 2.3       | 7 1.8   | 5 1.8     | 1 0.16      | 15 1.6      | 10 1.6     |
|                |              |         |           |             |             |            |
| 30 days        | 41 4.0       | 13 3.4  | 9 3.2     | 2 0.20      | 25 4.2      | 14 2.2     |
|                |              |         |           |             |             |            |
| 60 days        | 59 5.8       | 17 4.4  | 19 6.7    | 0.039       | 25 5.5      | 29 4.6     |
| 90 days        | 82 8.1       | 20 5.2  | 25 8.9    | 0.039       | 52 5.5      | 38 6       |

1 M-TURP was the reference method. 2 N/A: Number of bleeding events in the HoLEP group was <3. According to the data protection policy of NHIRD, data less than 3 cannot be provided. 3 Bleeding events leading to emergency room visits. 4 Bleeding events leading to rehospitalization. p values marked in bold indicate statistically significant differences between the groups. Abbreviations: CCI, Charlson comorbidity index; HCD, hypertensive cardiovascular disease; DM, diabetes mellitus; CKD, chronic kidney disease; ACEI, angiotensin-converting enzyme inhibitor; M-TURP, Monopolar transurethral resection of the prostate; B-TURP, Bipolar transurethral resection of the prostate; PVP, GreenLight Photovaporization of the prostate; ThuVARP, Thulium Laser Vaporesection of the Prostate; HoLEP, Holmium laser enucleation of the prostate; DiLEP, Diode laser (980 nm) enucleation of the Prostate. ACEI, angiotensin-converting enzyme inhibitor; HR, hazard ratio.
Table 4. Adjusted hazard ratios for emergency room visits due to postoperative bleeding after 15, 30, 60, and 90 days of surgery.

|                      | 15 Days HR (95% CI) | p  | 30 Days HR (95% CI) | p  | 60 Days HR (95% CI) | p  | 90 Days HR (95% CI) | p  |
|----------------------|---------------------|----|---------------------|----|---------------------|----|---------------------|----|
| **Age**              |                     |    |                     |    |                     |    |                     |    |
| 50–59 (As Reference) | 0.94 (0.55–1.60)    | 0.824 | 0.98 (0.60–1.60) | 0.941 | 1.00 (0.63–1.59) | 0.992 | 1.03 (0.66–1.62) | 0.894 |
| 60–69                | 0.98 (0.58–1.68)    | 0.947 | 0.95 (0.58–1.55) | 0.832 | 1.14 (0.72–1.81) | 0.585 | 1.12 (0.71–1.77) | 0.615 |
| >80                  | 1.11 (0.63–1.97)    | 0.715 | 1.12 (0.66–1.88) | 0.684 | 1.29 (0.79–2.11) | 0.316 | 1.32 (0.81–2.13) | 0.265 |
| **Charlson Comorbidity Index** |                   |    |                     |    |                     |    |                     |    |
| 0 (As Reference)     |                     |    |                     |    |                     |    |                     |    |
| 1–2                  | 1.87 (1.06–3.29)    | 0.03 | 1.91 (1.14–3.20) | 0.014 | 1.92 (1.20–3.08) | 0.007 | 1.97 (1.24–3.12) | 0.004 |
| 3–4                  | 2.01 (1.10–3.67)    | 0.023 | 1.88 (1.08–3.28) | 0.026 | 1.96 (1.19–3.25) | 0.009 | 2.06 (1.26–3.37) | 0.004 |
| >4                   | 2.35 (1.27–4.34)    | 0.006 | 2.37 (1.35–4.16) | 0.003 | 2.30 (1.37–3.85) | 0.002 | 2.36 (1.43–3.92) | 0.001 |
| **DM**               | 0.86 (0.63–1.17)    | 0.348 | 0.98 (0.74–1.30) | 0.89 | 1.03 (0.80–1.33) | 0.821 | 1.07 (0.83–1.37) | 0.605 |
| **HCD**              | 1.23 (0.83–1.83)    | 0.301 | 1.25 (0.88–1.80) | 0.217 | 1.19 (0.86–1.66) | 0.292 | 1.13 (0.82–1.56) | 0.442 |
| **CKD**              | 1.21 (0.84–1.76)    | 0.308 | 1.25 (0.89–1.75) | 0.203 | 1.15 (0.84–1.58) | 0.392 | 1.15 (0.84–1.57) | 0.39  |
| Hyperlipidemia       | 1.14 (0.82–1.58)    | 0.44 | 1.04 (0.77–1.41) | 0.779 | 1.00 (0.75–1.32) | 0.999 | 1.01 (0.76–1.32) | 0.967 |
| Heart failure        | 1.06 (0.78–1.44)    | 0.702 | 1.01 (0.76–1.34) | 0.947 | 1.01 (0.78–1.31) | 0.95 | 1.03 (0.80–1.33) | 0.803 |
| Statins              | 0.96 (0.70–1.32)    | 0.802 | 1.02 (0.76–1.36) | 0.911 | 1.08 (0.82–1.41) | 0.598 | 1.03 (0.79–1.34) | 0.835 |
| ACEI                 | 1.08 (0.79–1.48)    | 0.615 | 1.03 (0.77–1.36) | 0.852 | 1.03 (0.79–1.34) | 0.82 | 1.08 (0.83–1.40) | 0.569 |
| β-blocker            | 1.38 (1.00–1.92)    | 0.05 | 1.39 (1.03–1.87) | 0.033 | 1.29 (0.98–1.69) | 0.065 | 1.26 (0.96–1.64) | 0.309 |
| Anticoagulant        | 0.64 (0.39–1.08)    | 0.093 | 0.75 (0.48–1.17) | 0.201 | 0.69 (0.45–1.05) | 0.084 | 0.69 (0.45–1.04) | 0.077 |
| Antiplatelet         | 1.59 (0.76–3.34)    | 0.217 | 1.34 (0.68–2.67) | 0.4 | 1.43 (0.76–2.68) | 0.268 | 1.28 (0.69–2.37) | 0.44  |
| Spironolactone       | 1.20 (0.82–1.76)    | 0.353 | 1.22 (0.86–1.73) | 0.262 | 1.28 (0.93–1.76) | 0.136 | 1.23 (0.90–1.69) | 0.195 |
| 5α reductase inhibitors | 1.20 (0.93–1.55) | 0.165 | 1.20 (0.95–1.52) | 0.129 | 1.17 (0.94–1.45) | 0.162 | 1.13 (0.91–1.40) | 0.254 |

*p*-values marked in bold indicate statistically significant differences between the groups. Abbreviations: CCI, Charlson comorbidity index; DM, diabetes mellitus; HCD, hypertensive cardiovascular disease; CKD, chronic kidney disease; ACEI, angiotensin-converting enzyme inhibitor; M-TURP, Monopolar transurethral resection of the prostate; B-TURP, Bipolar transurethral resection of the prostate; PVP, GreenLight Photo vaporization of the prostate; ThuVARP, Thulium Laser Vaporesection of the Prostate; HoLEP, Holmium laser enucleation of the prostate; DiLEP, Diode laser (980nm) enucleation of the Prostate. ACEI, angiotensin-converting enzyme inhibitor; HR, hazard ratio.
Table 5. Adjusted hazard ratios for rehospitalization due to postoperative bleeding after 15, 30, 60, and 90 days of surgery.

|                  | 15 Days HR (95% CI) | p    | 30 Days HR (95% CI) | p    | 60 Days HR (95% CI) | p    | 90 Days HR (95% CI) | p    |
|------------------|---------------------|------|---------------------|------|---------------------|------|---------------------|------|
| Age              |                     |      |                     |      |                     |      |                     |      |
| 50–59 (As Reference) |                    |      |                     |      |                     |      |                     |      |
| 60–69            | 1.61 (0.37–7.11)    | 0.528| 1.39 (0.54–3.60)    | 0.498| 1.38 (0.65–2.93)    | 0.408| 1.21 (0.63–2.31)    | 0.571|
| 70–79            | 2.63 (0.61–11.2)    | 0.194| 1.43 (0.55–3.73)    | 0.46 | 1.58 (0.74–3.35)    | 0.238| 1.68 (0.88–3.19)    | 0.115|
| >80              | 2.69 (0.6–12.14)    | 0.198| 2.20 (0.83–5.87)    | 0.114| 2.69 (1.24–5.81)    | 0.012| 2.93 (1.52–5.65)    | 0.001|
| Charlson Comorbidity Index |                 |      |                     |      |                     |      |                     |      |
| 0 (As Reference) |                     |      |                     |      |                     |      |                     |      |
| 1–2              | 1.19 (0.41–3.44)    | 0.752| 1.00 (0.47–2.11)    | 0.998| 1.01 (0.58–1.77)    | 0.973| 1.06 (0.64–1.73)    | 0.829|
| 3–4              | 1.34 (0.43–4.18)    | 0.609| 1.21 (0.54–2.70)    | 0.638| 1.07 (0.58–1.97)    | 0.84 | 1.14 (0.66–1.95)    | 0.641|
| >4               | 1.82 (0.57–5.77)    | 0.309| 1.49 (0.65–3.40)    | 0.349| 1.25 (0.66–2.38)    | 0.496| 1.15 (0.65–2.03)    | 0.639|
| DM               | 1.15 (0.63–2.10)    | 0.654| 1.08 (0.67–1.73)    | 0.748| 1.08 (0.74–1.58)    | 0.688| 1.20 (0.87–1.66)    | 0.274|
| HCD              | 0.67 (0.32–1.42)    | 0.296| 0.97 (0.54–1.73)    | 0.917| 0.81 (0.52–1.27)    | 0.362| 0.77 (0.52–1.14)    | 0.188|
| CKD              | 0.98 (0.46–2.10)    | 0.962| 1.39 (0.80–2.39)    | 0.24 | 1.39 (0.89–2.16)    | 0.149| 1.44 (0.98–2.11)    | 0.065|
| Hyperlipidemia   | 1.00 (0.53–1.88)    | 0.988| 0.87 (0.53–1.43)    | 0.585| 0.80 (0.54–1.20)    | 0.28 | 0.92 (0.65–1.30)    | 0.633|
| Heart failure    | 1.48 (0.79–2.79)    | 0.219| 1.14 (0.71–1.83)    | 0.598| 1.24 (0.85–1.82)    | 0.265| 1.35 (0.97–1.89)    | 0.079|
| Statins          | 0.69 (0.36–1.31)    | 0.255| 0.79 (0.48–1.30)    | 0.35 | 0.92 (0.61–1.37)    | 0.667| 0.88 (0.63–1.25)    | 0.478|
| ACEI             | 0.89 (0.48–1.65)    | 0.706| 0.90 (0.56–1.46)    | 0.68 | 0.99 (0.68–1.44)    | 0.952| 1.04 (0.75–1.45)    | 0.795|
| β-blocker        | 1.19 (0.62–2.28)    | 0.602| 1.18 (0.72–1.92)    | 0.518| 0.99 (0.68–1.44)    | 0.956| 1.11 (0.80–1.55)    | 0.529|
| Anticoagulant    | 1.33 (0.63–2.82)    | 0.454| 1.21 (0.65–2.24)    | 0.547| 1.01 (0.59–1.71)    | 0.977| 0.91 (0.56–1.46)    | 0.685|
| Antiplatelet     | 1.58 (0.35–7.21)    | 0.557| 0.88 (0.30–2.64)    | 0.823| 1.25 (0.53–2.96)    | 0.614| 1.29 (0.61–2.73)    | 0.501|
| Spironolactone   | 1.09 (0.52–2.29)    | 0.816| 1.34 (0.77–2.32)    | 0.295| 1.14 (0.72–1.81)    | 0.582| 1.16 (0.78–1.72)    | 0.475|
| 5α reductase inhibitors | 1.65 (1.00–2.74) | 0.052| 1.48 (1.01–2.19)    | **0.047**| 1.56 (1.14–2.11)    | **0.005**| 1.30 (0.99–1.69)    | 0.057|
| Surgery type     |                     |      |                     |      |                     |      |                     |      |
| M-TURP (As Reference) |                 |      |                     |      |                     |      |                     |      |
| PVP              | 0.77 (0.33–1.80)    | 0.55 | 0.82 (0.44–1.53)    | 0.526| 0.72 (0.42–1.24)    | 0.243| 0.61 (0.38–1.00)    | **0.05**|
| DiLLEP           | 0.75 (0.28–1.98)    | 0.561| 0.78 (0.38–1.61)    | 0.5  | 1.15 (0.69–1.94)    | 0.59 | 1.12 (0.71–1.75)    | 0.634|
| HoLEP            | 1.00 (0.13–7.45)    | 0.996| 0.57 (0.08–4.19)    | 0.584| 0.36 (0.05–2.74)    | 0.337| 0.54 (0.13–2.22)    | 0.397|
| ThuVARP          | 0.69 (0.36–1.33)    | 0.271| 0.65 (0.39–1.07)    | 0.089| 0.71 (0.47–1.06)    | 0.092| 0.67 (0.47–0.95)    | **0.024**|
| B-TURP           | 0.70 (0.33–1.47)    | 0.346| 0.54 (0.29–1.00)    | **0.049**| 0.77 (0.49–1.20)    | 0.249| 0.73 (0.50–1.08)    | 0.117|

*p*-values marked in bold indicate statistically significant differences between the groups. Abbreviations: CCI, Charlson comorbidity index; DM, diabetes mellitus; HCD, hypertensive cardiovascular disease; CKD, chronic kidney disease; ACEI, angiotensin-converting enzyme inhibitor; M-TURP, Monopolar transurethral resection of the prostate; B-TURP, Bipolar transurethral resection of the prostate; PVP, GreenLight Photo vaporization of the prostate; ThuVARP, Thulium Laser Vaporesection of the Prostate; HoLEP, Holmium laser enucleation of the prostate; DiLLEP, Diode laser (980 nm) enucleation of the Prostate. ACEI, angiotensin-converting enzyme inhibitor; HR, hazard ratio.
Regarding bleeding events leading to ER visits, the 90-day cumulative incidence of emergency room (ER) visits with postoperative bleeding was compared between different surgery groups. Abbreviations: M-TURP, Monopolar transurethral resection of the prostate; B-TURP, Bipolar transurethral resection of the prostate; PVP, GreenLight Photovaporization of the prostate; ThuVARP, Thulium Laser Vaporesection of the Prostate; HoLEP, Holmium laser enucleation of the prostate; DiLEP, Diode laser (980 nm) enucleation of the Prostate.

Figure 3. (A) Cumulative incidence of emergency room (ER) visits with postoperative bleeding post TURP and laser surgery. (B) Cumulative incidence of ER visits due to postoperative bleeding post different surgery groups. Abbreviations: M-TURP, Monopolar transurethral resection of the prostate; B-TURP, Bipolar transurethral resection of the prostate; PVP, GreenLight Photovaporization of the prostate; ThuVARP, Thulium Laser Vaporesection of the Prostate; HoLEP, Holmium laser enucleation of the prostate; DiLEP, Diode laser (980 nm) enucleation of the Prostate.

Figure 4. (A). Cumulative incidence of rehospitalization due to postoperative bleeding after TURP and laser surgery. (B). Cumulative incidence of rehospitalization due to postoperative bleeding in different surgery groups. Abbreviations: M-TURP, Monopolar transurethral resection of the prostate; B-TURP, Bipolar transurethral resection of the prostate; PVP, GreenLight Photovaporization of the prostate; ThuVARP, Thulium Laser Vaporesection of the Prostate; HoLEP, Holmium laser enucleation of the prostate; DiLEP, Diode laser (980 nm) enucleation of the Prostate.

4. Discussion

To the best of our knowledge, our study is the first to compare six transurethral procedures for the treatment of BPH or lower urinary tract infection and to investigate differences in postoperative bleeding. No study has compared six transurethral procedures by using balanced baseline characteristics.

4.1. Participants in Balanced Groups

We presented the results of laser surgery and TURP with adjustments for demographics, comorbidities, and comediations by using PSM. Most studies did not perform a multivariate analysis with adjustments for confounders [5]. We adjusted the outcomes be-
between the age, comorbidities, and comedication cohorts. In order to avoid the inconsistency of comorbidities, we used CCI [23].

4.2. Main Results

Most studies reported shorter hospitalization durations with PVP, ThuVARP, DiLEP, and HoLEP than with TURP [24–27]. Some smaller studies reported no significant differences in hospitalization duration between HoLEP and B-TURP [25,28]. Our study revealed significantly shorter hospitalization durations with PVP, ThuVARP, and DiLEP than with M-TURP but not with HoLEP and B-TURP.

Shamout et al. reported that 28.6% and 11.1% of the patients returned to ER or were rehospitalized post-M-TURP, respectively. This was higher than in our study [29]. In another study, the reported the percentage of patients who returned to ER or were rehospitalized post-M-TURP (8.0%, 2.8%), HoLEP (9.8%, 0.9%), and PVP (7.5%, 1.7%) was lower than in our study [30].

The evidence involving ThuVARP and DiLEP and their bleeding risk and other complications is still scarce [31]. Therefore, we believe that a complete follow-up study of all six transurethral procedures is needed to be able to fully compare and balance their risk/benefit.

4.3. Differences in Postoperative Bleeding between Different Surgery Types

Early postoperative bleeding is a frequent complication occurring within 1 to 3 months after BPH surgery [32,33] and is treated with bladder irrigation and clot removal, if necessary [34].

PVP and ThuVARP are safer than M-TURP because blood transfusion, clot retention, hemoglobin decline, or transurethral resection syndrome is less likely to occur [35]. Our findings support changes in the surgical treatment of BPH from M-TURP to new laser methods [24,36,37]. However, DiLEP and HoLEP resulted in more bleeding events than M-TURP. Early DiLEP and HoLEP therapies are associated with increased postoperative complications, although some later studies reported lower morbidity in patients undergoing these therapies [38,39].

4.4. Comparison between the Subgroups of Demographics, Comorbidities, and Comedications

The high CCI score subgroup demonstrated increased HRs for ER visits within 90 days after surgery, whereas patients aged >80 years exhibited a significant risk of bleeding leading to rehospitalization. Our study suggested that laser surgery is safer than M-TURP for BPH because of reduced catheter time and risk of bleeding, even in patients receiving anticoagulant or antiplatelet therapy [23,35,40].

We investigated four types of laser surgery and two types of TURP and demonstrated that laser therapies are associated with a shorter hospital stay, less bleeding, and lower transfusion requirements than TURP, even in patients receiving anticoagulant or antiplatelet therapy [41,42]. However, the rates of ER visits and rehospitalization revealed that DiLEP and HoLEP were not associated with reduced bleeding complications [43,44]. In the recent decade, favorable outcomes were obtained after laser surgery, but a high percentage of urologists still prefer TURP. This may be because of the perceived precipitous learning curve of laser surgery [45–47].

4.5. Limitations

First, we used a retrospective cohort design. We matched all potential confounders between the surgery cohorts, but the selection and observational bias may still exist. Meanwhile, the sample size differs between all sub-groups studied, and this may result in bias. However, the use of data from the NHIRD, a large and well-validated database, may control the bias.

The second limitation is the accuracy of diagnosis. Potential misdiagnosis exists in the NHIRD because of the possible misclassification of ICD-9-CM and ICD-10-CM codes.
Third, the NHIRD lacks specific clinical (e.g., the weight of the resected prostate, catheterization time, and hemoglobin decline) and lifestyle behavior (e.g., Body Mass Index, smoking behavior, and alcohol use) data.

Finally, the study lacks information regarding the surgeons’ experience and training. These limitations do not compromise the conclusions of this study. However, large-scale prospective studies should be conducted to further validate our results.

5. Conclusions

Among the six investigated, transurethral procedures for BPH, PVP, and ThuVARP were safer than M-TURP because bleeding events and clot retention were less likely to occur, even in patients receiving anticoagulant or antiplatelet therapy. However, DiLEP and HoLEP did not result in fewer bleeding events than M-TURP. Our findings suggest that PVP and ThuVARP are effective alternatives to M-TURP for the surgical treatment of BPH. These results would provide useful information for urologists and patients with BPH.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Show Chwan Memorial Hospital (IRB-No: 1091213) for studies involving humans.

Informed Consent Statement: According to the THIRD dataset incorporating encrypted secondary data, all participants are unfeasible to be identified; hence, the informed consent requirement was waived.

Data Availability Statement: The personal electronic data of NHIRD protects by the Computer-Processed Personal Data Protection Law. The results of the academic study are available for researchers from the NHIRD of Taiwan. All researchers accord with the criteria for access to confidential data, which cannot be shared publicly because of legal guidelines imposed by the government of Taiwan under the “Personal Information Protection Act”. Requests for data can be applied as an official proposal to the NHIRD (https://dep.mohw.gov.tw/dos/np-2497-113.html (accessed on 7 August 2022)). The contact information for needed data is: 886-2-85906828; Email: sthuiying@mohw.gov.tw.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

| Abbreviation | Meaning |
|--------------|---------|
| ACEIs        | angiotensin-converting enzyme inhibitors |
| BPH          | benign prostatic hyperplasia |
| B-TURP       | bipolar transurethral resection of the prostate |
| CCI          | Charlson comorbidity index |
| CI           | confidence interval |
| CKD          | chronic kidney disease |
| DiLEP        | diode laser (980 nm) enucleation of the prostate |
| DM           | diabetes mellitus |
| ER           | emergency room |
| HCD          | hypertensive cardiovascular disease |
| HoLEP        | holmium laser enucleation of the prostate |
| HR           | hazard ratio |
| ICD-10-CM    | International Classification of Diseases, Ten Revision, Clinical Modification |
| ICD-9-CM     | International Classification of Diseases, Ninth Revision, Clinical Modification |
| IRB          | Institutional Review Board |
M-TURP: monopolar transurethral resection of the prostate
NHI: National Health Insurance
NHIRD: National Health Insurance Research Database
PSM: propensity score matching
PVP: GreenLight photovaporization of the prostate
SD: standard deviation
ThuVARP: thulium laser vaporesection of the prostate
TURP: transurethral resection of the prostate

References
1. McVary, K.T. BPH: Epidemiology and comorbidities. Am. J. Manag. Care 2006, 12 (Suppl. S5), S122–S128. [PubMed]
2. Kailavasan, M.; Berridge, C.; Athanasiadis, G.; Gkentzis, A.; Rai, B.; Jain, S.; Biyani, C.S.; Nabi, G. Design, implementation, and evaluation of a novel curriculum to teach transurethral resection of the prostate (TURP): A 3-year experience of urology simulation bootcamp course. World J. Urol. 2020, 38, 2899–2906. [CrossRef] [PubMed]
3. Akman, T.; Binbay, M.; Tekinarslan, E.; Tepeler, A.; Akcay, M.; Ozgor, F.; Ugurlu, M.; Muslimanoglu, A. Effects of bipolar and monopolar transurethral resection of the prostate on urinary and erectile function: A prospective randomized comparative study. BJUI Int. 2013, 111, 129–136. [CrossRef] [PubMed]
4. Chin, P.T.; Bolton, D.M.; Jack, G.; Rashid, P.; Thavaseelan, J.; Yu, R.J.; Roehrborn, C.G.; Woo, H.H. Prostatic urethral lift: Two-year results after treatment for lower urinary tract symptoms secondary to benign prostatic hyperplasia. Urology 2012, 79, 5–11. [CrossRef]
5. Corru, J.-N.; Ahyai, S.; Bachmann, A.; de la Rosette, J.; Gilling, P.; Gratzke, C.; McVary, K.; Novara, G.; Woo, H.; Madensbacher, S. A systematic review and meta-analysis of functional outcomes and complications following transurethral procedures for lower urinary tract symptoms resulting from benign prostatic obstruction: An update. Eur. Urol. 2015, 67, 1066–1096. [CrossRef]
6. Kim, M.; Lee, H.-E.; Oh, S.-J. Technical aspects of holmium laser enucleation of the prostate for benign prostatic hyperplasia. Korean J. Urol. 2013, 54, 570–579. [CrossRef]
7. Nair, S.M.; Pimentel, M.A.; Gilling, P.J. A review of laser treatment for symptomatic BPH (benign prostatic hyperplasia). Curr. Urol. Rep. 2016, 17, 45. [CrossRef]
8. Kahokehr, A.A.; Gilling, P.J. Which laser works best for benign prostatic hyperplasia? Curr. Urol. Rep. 2013, 14, 614–619. [CrossRef]
9. Gravas, S.; Bachmann, A.; Reich, O.; Roehrborn, C.G.; Gilling, P.J.; De La Rosette, J. Critical review of lasers in benign prostatic hyperplasia (BPH). BJU Int. 2011, 107, 1030–1043. [CrossRef]
10. Hsieh, C.-Y.; Su, C.-C.; Shao, S.-C.; Sung, S.-F.; Lin, S.-J.; Yang, Y.-H.K.; Lai, E.C.-C. Taiwan’s national health insurance research database: Past and future. Clin. Epidemiol. 2019, 11, 549. [CrossRef]
11. Hsiao, F.-Y.; Yang, C.-L.; Huang, Y.-T.; Huang, W.-F. Using Taiwan’s national health insurance research databases for pharmacoepidemiology research. J. Food Drug Analysis. 2007, 15, 7. [CrossRef]
12. Hsu, M.C.; Wang, C.C.; Huang, L.Y.; Lin, C.Y.; Lin, F.J.; Toh, S. Effect of ICD-9-CM to ICD-10-CM coding system transition on identification of common conditions: An interrupted time series analysis. Pharmacoepidemiol. Drug Safety. 2021, 30, 1653–1674. [CrossRef]
13. Issa, M.M. Technological advances in transurethral resection of the prostate: Bipolar versus monopolar TURP. J. Endourol. 2008, 22, 1587–1596. [CrossRef]
14. Alexander, C.E.; Scullion, M.M.F.; Omar, M.I.; Yuan, Y.; Mamoulakis, C.; N’Dow, J.M.O.; Lam, T.B.L. Cochrane Urology Group Bipolar versus monopolar transurethral resection of the prostate for lower urinary tract symptoms secondary to benign prostatic obstruction. Cochrane Database Syst. Rev. 2019, 12, 12. [CrossRef]
15. Foster, H.E.; Barry, M.J.; Dahm, P.; Gandhi, M.C.; Kaplan, S.A.; Kohler, T.S.; McVary, K.T. Surgical management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA guideline. J. Urol. 2018, 200, 612–619. [CrossRef]
16. Lerner, L.B.; McVary, K.T.; Barry, M.J.; Bixler, B.R.; Dahm, P.; Das, A.K.; Wilt, T.J. Management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA guideline part II—surgical evaluation and treatment. J. Urol. 2021, 206, 818–826. [CrossRef]
17. Austin, P.C. A critical appraisal of propensity-score matching in the medical literature between 1996 and 2003. Stat. Med. 2008, 27, 2037–2049. [CrossRef]
18. Redelmeier, D.A.; Tibshirani, R.J. A simple method for analyzing matched designs with double controls: McNemar’s test can be extended. J. Clin. Epidemiol. 2017, 81, 51–55. [CrossRef]
19. Martens, E.P.; de Boer, A.; Pestman, W.R.; Belitzer, S.V.; Stricker, B.H.C.; Klungel, O.H. Comparing treatment effects after adjustment with multivariable Cox proportional hazards regression and propensity score methods. Pharmacoepidemiol. Drug Saf. 2008, 17, 1–8. [CrossRef]
20. Kleinbaum, D.G.; Klein, M. Kaplan-Meier survival curves and the log-rank test. In Survival Analysis; Springer: New York, NY, USA, 2012; pp. 55–96.
21. Caliendo, M.; Kopeinig, S. Some practical guidance for the implementation of propensity score matching. *J. Econ. Surv.* 2008, 22, 31–72. [CrossRef]

22. Abadie, A.; Spiess, J. Robust post-matching inference. *J. Am. Stat. Assoc.* 2022, 117, 983–995. [CrossRef]

23. Austin, S.R.; Wong, Y.-N.; Uzzo, R.G.; Beck, J.R.; Egleston, B.L. Why summary comorbidity measures such as the Charlson comorbidity index and Elixhauser score work. *Med. Care* 2015, 53, e65. [CrossRef]

24. Chen, Y.-B.; Chen, Q.; Wang, Z.; Peng, Y.-B.; Ma, L.-M.; Zheng, D.-C.; Cai, Z.-K.; Li, W.-J.; Ma, L.-H. A prospective, randomized clinical trial comparing plasmakinetic resection of the prostate with holmium laser enucleation of the prostate based on a 2-year followup. *J. Urol.* 2013, 189, 217–222. [CrossRef]

25. Yang, Z.; Wang, X.; Liu, T. Thulium laser enucleation versus plasmakinetic resection of the prostate: A randomized prospective trial with 18-month follow-up. *Urology* 2013, 81, 396–401. [CrossRef]

26. Castellani, D.; Pirolo, G.M.; Rubilotta, E.; Guibbiotti, M.; Scarcella, S.; Maggi, M.; Gauhar, V.; Toeh, J.Y.-C.; Galosi, A.B. GreenLight Laser™ Photovaporization versus Transurethral Resection of the Prostate: A Systematic Review and Meta-Analysis. *Res. Rep. Urol.* 2021, 13, 263. [CrossRef]

27. Wu, G.; Hong, Z.; Li, C.; Bian, C.; Huang, S.; Wu, D. A comparative study of diode laser and plasmakinetic in transurethral enucleation of the prostate for treating large volume benign prostatic hyperplasia: A randomized clinical trial with 12-month follow-up. *Lasers Med. Sci.* 2016, 31, 599–604. [CrossRef]

28. Habib, E.; Abdallah, M.F.; Elsheemy, M.S.; Badawy, M.H.; Nour, H.H.; Kamal, A.M.; AbdelMohsen, M.; Rosshdy, M.A.; Meshref, A. Holmium laser enucleation versus bipolar resection in the management of large-volume benign prostatic hyperplasia: A randomized controlled trial. *Int. J. Urol.* 2022, 29, 128–135. [CrossRef]

29. Shamout, S.; Carlson, K.; Brotherhood, H.L.; Crump, T.; Bavérostock, R. Incidence and predictors of early and late hospital readmission after transurethral resection of the prostate: A population-based cohort study. *BJU Int.* 2021, 127, 238–246. [CrossRef]

30. Okamura, K.; Nishi, M.; Seki, N.; Arai, Y.; Matsuda, T.; Hattori, R.; Naito, S. Perioperative management of transurethral surgery for benign prostatic hyperplasia: A nationwide survey in Japan. *Int. J. Urol.* 2011, 18, 304–310. [CrossRef]

31. Kim, A.; Hak, A.-J.; Choi, W.S.; Paick, S.H.; Kim, H.G.; Park, H. Comparison of long-term effect and complications between holmium laser enucleation and transurethral resection of prostate: A case report and a review of the literature. *Int. J. Urol.* 2014, 21, 215–217. [CrossRef] [PubMed]

32. Reich, O.; Gratzke, C.; Bachmann, A.; Seitz, M.; Schlenker, B.; Hermanek, P.; Lack, N.; Stief, C.G.; Urology Section of the Bavarian Working Group for Quality Assurance. Morbidity, mortality and early outcome of transurethral resection of the prostate: A prospective multicenter evaluation of 10,654 patients. *J. Urol.* 2008, 180, 246–249. [CrossRef] [PubMed]

33. Cornu, J.N.; Herrmann, T.; Traxer, O.; Matlaga, B. Prevention and management following complications from endourology procedures. *Eur. Urol. Focus* 2016, 2, 49–59. [CrossRef] [PubMed]

34. Teng, T.-C.; Shao, I.-H.; Hsu, Y.-C.; Chen, Y.; Tsao, S.-H.; Kang, Y.-T.; Hsieh, M.-L. Risk Factors of Emergency Room Visits for Bleeding Complications Following Transurethral Procedures in the Treatment of Benign Prostatic Hyperplasia: A Retrospective Cohort Study. *Clin. Interv. Aging* 2021, 16, 1747. [CrossRef]

35. Kim, A.; Hak, A.-J.; Choi, W.S.; Paick, S.H.; Kim, H.G.; Park, H. Comparison of long-term effect and complications between holmium laser enucleation and transurethral resection of prostate: Nations-wide health insurance study. *Urology* 2021, 154, 300–307. [CrossRef]

36. Kurtz, R.M.; Ahyai, S.; Lehrich, K.; Fayad, A.M.R. Transurethral holmium laser enucleation versus transurethral electrocautery resection of the prostate: A randomized prospective trial in 200 patients. *J. Urol.* 2004, 172, 1012–1016. [CrossRef]

37. Rieken, M.; Bachmann, A. Laser treatment of benign prostate enlargement—Which laser for which prostate? *Nat. Rev. Urol.* 2014, 11, 142–152. [CrossRef]

38. Elkousy, M.A.; Elhilali, M.M. Management of Benign Prostatic Hyperplasia Larger than 100 ml: Simple Open Enucleation Versus Transurethral Laser Prostatectomy. *J. Urol. Reports.* 2016, 17, 44. [CrossRef]

39. Rivera, M.; Krambeck, A.; Lingeman, J. Holmium laser enucleation of the prostate in patients requiring anticoagulation. *Curr. Urol. Rep.* 2017, 18, 77. [CrossRef]

40. Yin, L.; Teng, J.; Huang, C.-J.; Zhang, X.; Xu, D. Holmium laser enucleation of the prostate versus transurethral resection of the prostate: A systematic review and meta-analysis of randomized controlled trials. *J. Endourol.* 2013, 27, 604–611. [CrossRef]

41. Gilling, P.J.; Wilson, L.C.; King, C.J.; Westenberg, A.M.; Frampton, C.M.; Fraundorfer, M.R. Long-term results of a randomized trial comparing holmium laser enucleation of the prostate and transurethral resection of the prostate: Results at 7 years. *BJU Int.* 2012, 109, 408–411. [CrossRef]

42. Elterman, D.S.; Chughtai, B.; Lee, R.; Kurlander, L.; Yip-Barrico, M.; Kaplan, S.A.; Te, A.E. Comparison of techniques for transurethral laser prostatectomy: Standard photoselective vaporization of the prostate versus transurethral laser enucleation of the prostate. *J. Endourol.* 2013, 27, 751–755. [CrossRef]

43. Elmansy, H.; Baazeem, A.; Kotb, A.; Badawy, H.; Riad, E.; Emran, A.; Elhilali, M. Holmium laser enucleation versus photoselective vaporization for prostate adenoma greater than 60 ml: Preliminary results of a prospective, randomized clinical trial. *J. Urol.* 2012, 188, 216–221. [CrossRef]
45. Kreydin, E.I.; Chyu, J.; Lerner, L. Laser prostate ablation and enucleation: Analysis of a national cohort. *Int. J. Urol.* **2018**, *25*, 549–553.

46. Malik, R.; Wang, C.; Lapin, B.; Gerber, G.; Helfand, B. Comparison of patients undergoing laser vaporization of the prostate versus TURP using the ACS-NSQIP database. *Prostate Cancer Prostatic Dis.* **2015**, *18*, 18–24.

47. Heidar, N.A.; Labban, M.; Misrai, V.; Mailhac, A.; Tamim, H.; El-Hajj, A. Laser enucleation of the prostate versus transurethral resection of the prostate: Perioperative outcomes from the ACS NSQIP database. *World J. Urol.* **2020**, *38*, 2891–2897. [CrossRef]