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CLINICIAN'S WORKSHOP

Prostate Disease

Bipolar transurethral enucleation of prostate versus photoselective vaporization for symptomatic benign prostatic hyperplasia (>70 ml)

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We prospectively compared the safety and efficacy of bipolar transurethral enucleation of the prostate (TUEP) versus 160-W lithium triboride laser (LBO) photoselective vaporization of the prostate (PVP) for treating benign prostatic hyperplasia >70 ml. Between February 2011 and December 2013, we treated 81 patients with benign prostatic hyperplasia >70 ml (39 using bipolar TUEP, 42 using PVP). There were no bleeding complications necessitating blood transfusion in either group. The operation time was comparable in the two groups (83.59 ± 12.96 vs 89.60 ± 20.18 min, $P = 0.277$). The PVP group had a shorter catheterization time (55.12 ± 36.00 vs 110.00 ± 24.57 h; $P < 0.001$) and postoperative stay (3.60 ± 1.78 vs 5.82 ± 1.05 days; $P < 0.001$) than the bipolar TUEP group. Neither group had severe perioperative complications. At 12 months postoperatively, the bipolar TUEP group had sustainable, statistically significant improvement according to the International Prostate Symptom Score (3.51 ± 1.67 vs 5.12 ± 2.31 ; $P = 0.001$), quality of life (0.75 ± 0.63 vs 1.24 ± 0.66 ; $P = 0.001$), maximum urinary flow rate (26.04 ± 5.04 vs 22.49 ± 4.93 ml s⁻¹; $P < 0.001$), postvoid residual urine volume (10.59 ± 4.62 vs 17.26 ± 5.35 ml; $P < 0.001$), and prostate-specific antigen level (1.26 ± 0.49 vs 2.20 ± 0.85 ng ml⁻¹; $P < 0.001$). Both bipolar TUEP and 160-W LBO PVP are safe and effective for treating benign prostatic hyperplasia >70 ml. Bipolar TUEP offers more complete removal of prostatic adenoma than 160-W LBO PVP. Our results indicated that the clinical efficacy of bipolar TUEP was more durable and favorable than 160-W LBO PVP at the 12-month follow-up.

Transurethral resection of the prostate (TURP) remains the standard surgical treatment for benign prostatic hyperplasia (BPH). However, it is associated with a high complication rate, including transurethral resection (TUR) syndrome, failure to void, a need for blood transfusion,¹ and myocardial arrhythmia.^{2,3} All these factors add up to a prolonged resection time.^{4–6} For these reasons, alternative surgical techniques have been developed with the aim to reduce the complications while maintaining efficacy, especially when treating large prostates. Bipolar transurethral enucleation of the prostate (TUEP) and

160-W lithium triboride laser (LBO) photoselective vaporization of the prostate (PVP) are two of them.

The bipolar device was recently introduced into the field of urology primarily for treating obstructive prostatic disease.^{7–9} Intraoperative blood loss was less with the bipolar device than with TURP.¹⁰ Bipolar TUEP was refined to enucleate prostate adenomas along the surgical capsule with the method just as holmium laser enucleation of the prostate (HoLEP), fragmenting prostate adenomas using the bipolar resection loop. This technique does not compromise the cost properties of the laser and requires no additional device to fragment the tissue. It has also proved to be a safe, technically feasible treatment for BPH,^{11,12} regardless of the size of the prostate.¹³

PVP has been shown to be as effective as TURP for managing bladder outlet obstruction, with less perioperative morbidity^{14,15} and independent of the prostate size. To improve vaporization efficiency, the PVP system was increased from 80 to 180-W. Although the efficiency of 160-W LBO PVP system in our department is lower than the 180-W PVP system typically used in the United States and Europe, it is effective and safe for treating BPH.¹⁶ Thus, we aimed to assess the safety and efficacy of bipolar TUEP compared with PVP for treating BPH >70 ml.

TECHNIQUE OUTLINE

Between February 2011 and December 2013, we prospectively enrolled 81 men with bladder outlet obstruction resulting from clinically diagnosed BPH >70 ml in the study. In all, 39 patients underwent bipolar TUEP in Jinan Central Hospital Affiliated to Shandong University, and 42 patients underwent PVP in Shandong Provincial Hospital Affiliated to Shandong University. The Ethics Committees of these hospitals approved the protocol.

Inclusion criteria for surgery were maximum urinary flow rate (Q_{max}) <15 ml s⁻¹, International Prostate Symptom Score (IPSS) >12, medication failure, recurrent urinary retention, and prostate volume >70 ml on transrectal ultrasonography (TRUS). Patients were excluded because of neurourologic dysfunction, prostate carcinoma, and/or a previous history of prostatic or urethral surgery. All

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patients were evaluated preoperatively by physical examination, digital rectal examination, and laboratory studies, including determination of the serum prostate-specific antigen (PSA) level, Q_{\max} , and postvoid residual urine volume (PVR).

Because of the nonrandomized, two-center nature of the study, different surgeons at different hospitals performed bipolar TUEP or PVP. All these surgeons were skilled in bipolar TUEP or PVP.

The bipolar TUEP procedure was performed under general or spinal anesthesia using a 26-Fr resectoscope (**Figure 1**). The bipolar system controller operates at 280-W cutting power and 80-W coagulation power. An inverted U-incision was started close to the verumontanum, and marks were made at the distal edge of the prostate lobes. The incisions were deepened until the surgical capsule of the prostate was reached. The prostate gland was peeled off the surgical capsule in retrograde fashion toward the bladder neck using the resectoscope tip combined with a loop. The loop was used to cut the connection between the adenoma and the prostatic capsule, when necessary, and to coagulate the denuded supply vessels and hemorrhagic spots on the capsule surface. Thus, the prostatic lobes were subtotally enucleated and devascularized but were still connected to the bladder neck by a narrow pedicle. The enucleated adenoma was resected in pieces rapidly and bloodlessly with the bipolar resection loop. When resection was complete, all adenoma fragments were extracted by Ellic. All retrieved tissue was collected and examined histologically.

The PVP procedure was performed with a PVP Green Laser Surgical System. The LBO laser energy was delivered by a 6-Fr side-deflecting fiber with a 23-Fr continuous-flow cystoscope (**Figure 2**). Physiologic saline was used as the irrigant. The power was set at 160-W at the start of the procedure. The bladder neck, median lobe, lateral lobe, and apical portion of the enlarged prostate were vaporized consecutively. The apical prostatic portion was vaporized precisely. The power was then turned down to 100-W. The vaporization procedure was stopped when a "TUR-like" cavity was obtained.

At the end of both procedures, a 20-Fr three-way Foley catheter was inserted into the bladder with a closed drainage system. Bladder irrigation was continued until hematuria had decreased sufficiently.

We collected data on perioperative parameters for both groups, including the operation time, changes in serum sodium and hemoglobin levels, the presence of TUR syndrome, the need for blood transfusion and catheterization, postoperative hospital stay, and adverse events. In addition, for the bipolar TUEP group, we recorded the weight of the retrieved prostatic tissue. The preoperative measures, including IPSS, quality of life (QoL) score, Q_{\max} , PVR, and PSA, were reassessed at 1, 3, 6, and 12 months postoperatively.

Statistical analysis was performed using SPSS 19.0 for Windows software (SPSS Inc., Chicago, IL, USA). The data are presented

as means \pm standard deviation. The baseline characteristics and perioperative data for the two groups were statistically analyzed using the Mann – Whitney U-test. Postoperative adverse events were evaluated using Fisher's exact test. The value of $P < 0.05$ was considered to indicate statistical significance.

The baseline characteristics of both groups are shown in **Table 1**. No significant difference was found in any aspect between the bipolar TUEP and PVP groups.

The mean operation time was 6.01 min shorter for the bipolar TUEP group, but the difference did not reach statistical significance. No significant difference was found between the two groups in terms of hemoglobin loss or sodium decrease. In the bipolar TUEP group, a mean 68.11 ± 12.72 g of prostatic tissue was resected. With PVP, the mean energy delivered was 383.17 ± 150.99 KJ. **Table 2** shows that the catheterization duration and hospitalization stay were longer for the bipolar TUEP group ($P < 0.001$).

Capsule perforation was observed in two patients (5.13%) in the bipolar TUEP group and one patient (2.38%) in the PVP group ($P = 0.606$). The postoperative and postdischarge complications for the two groups are shown in **Table 3**. There was no clinically significant intraoperative bleeding, no blood transfusion, and no evidence of TUR syndrome in either group. No patients in either group underwent recatheterization because of urinary retention after catheter removal. Two patients in each group (5.13% in the bipolar TUEP group, 4.76% in the PVP group) experienced incontinence after removing

Table 1: Baseline characteristics of the two groups

Characteristic	TUEP (n=39)	PVP (n=42)	P
Age (years)	71.15 \pm 6.33	70.45 \pm 5.52	0.190
IPSS	22.87 \pm 5.00	21.60 \pm 5.12	0.286
Q_{\max} (ml s ⁻¹)	5.75 \pm 2.76	5.73 \pm 3.33	0.653
PSA (ng ml ⁻¹)	6.01 \pm 3.43	5.55 \pm 2.72	0.966
Prostate size (ml)	88.32 \pm 21.28	83.07 \pm 10.90	0.435
PVR (ml)	123.18 \pm 103.63	135.86 \pm 117.02	0.755
QoL	4.55 \pm 0.90	4.68 \pm 0.88	0.484
Hemoglobin (g dl ⁻¹)	12.67 \pm 1.51	12.62 \pm 1.40	0.947
Serum sodium (mmol l ⁻¹)	138.13 \pm 2.26	138.17 \pm 1.96	0.646

Statistically significant at $P < 0.05$. TUEP: transurethral enucleation of prostate; PVP: photoselective vaporization of the prostate; IPSS: International Prostate Symptom Score; PSA: prostate-specific antigen; PVR: postvoid residual (urine volume); QoL: quality of life

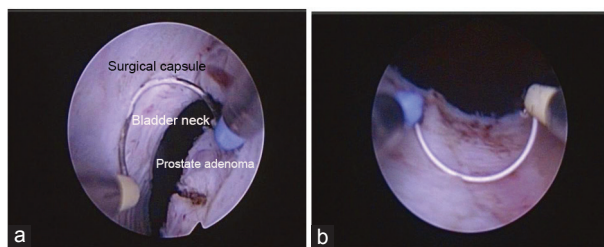


Figure 1: (a) Endoscopic image shows smooth plane between the prostate adenoma and surgical capsule using the enucleation technique; **(b)** the end point of TUEP. TUEP: transurethral enucleation of the prostate.



Figure 2: The end point of PVP. PVP: photoselective vaporization of the prostate.

the urethral catheter, which was relieved by pelvic floor exercises. Two patients (5.13%) in the bipolar TUEP group and 3 (7.14%) in the PVP group were diagnosed with a urinary tract infection. The irritative symptoms were eased after administering sensitive antibiotics. Transient, mild to moderate dysuria was observed in 5.13% ($n = 2$) of patients in the bipolar TUEP group and in 11.90% ($n = 5$) of patients in the PVP group. During the follow-up, urethral stricture occurred in 2.56% ($n = 1$) of patients in the bipolar TUEP group and 4.76% ($n = 2$) of patients in the PVP group. The strictures were solved by dilation. We found no patients with bladder neck contracture requiring a transurethral incision in either group.

All patients were available for the 12-month follow-up. Dramatic improvement in subjective and objective voiding parameters was observed in both groups, but more significant improvement was found in the bipolar TUEP group (Figure 3). At the endpoint, the mean PSA value had decreased to 1.26 ng ml⁻¹ in the bipolar TUEP group and to 2.20 ng ml⁻¹ in the PVP group. The mean IPSS had improved to 3.51 in the bipolar TUEP group and to 5.12 in the PVP group. The Q_{max} had improved to 26.04 ml s⁻¹ in the bipolar TUEP group and to 22.49 ml s⁻¹ in the PVP group. The QoL had improved to 0.75 in the bipolar TUEP group and to 1.24 in the PVP group. The PVR had decreased to 10.59 ml in the bipolar TUEP group and to 17.26 ml in the PVP group. All the changes in these parameters were statistically significant.

COMMENTS

TURP is currently the standard minimally invasive surgical treatment for BPH. The main complication of TURP when treating large prostates, however, is bleeding, which is a significant contributor

to cardiovascular complications, often requiring transfusion. Kwon *et al.*¹⁷ reported a 15.7% transfusion rate when using TURP to treat large prostates. Premature termination of the procedure may be necessary, resulting in inadequate relief of the obstruction. A second intervention may be the consequence. The risk for perioperative complications of TURP increases with the increasing amount of resected prostatic tissue.

HoLEP has been known to be safe and effective for treating BPH of any size since Gilling *et al.*¹⁸ introduced transurethral enucleation of the prostate using holmium laser. The main limitations of HoLEP are the steep learning curve^{19,20} and the high cost.^{21,22} In this study, we used bipolar TUEP, which operates on the same principles as HoLEP: identification of the tissue plane between the surgical capsule and the adenoma, detachment of the adenoma along the capsule, and morcellation of the prostate adenoma using a different type of energy, which is easy to learn. Neill *et al.*²³ reported that bipolar TUEP removed an amount of tissue similar to that removed by HoLEP, but that bipolar TUEP was more cost effective.

In our study, we detached the prostate adenoma along the surgical capsule in a retrograde fashion, from the verumontanum toward the bladder neck. Because the entire prostate was devascularized but still attached to the bladder neck with a narrow pedicle after detachment from the capsule, the devascularized prostate adenoma could be resected in pieces small enough to evacuate rapidly through the resectoscope sheath in a nearly bloodless fashion with the bipolar resection loop. These characteristics helped the bipolar TUEP procedure achieve complete tissue removal with excellent operative field visibility. There was also a significant increase in the resection speed with a low capsular perforation rate. A mechanical tissue morcellator was not required, minimizing the treatment costs and avoiding bladder mucosal injury. Two patients in the bipolar TUEP group experienced a small capsule perforation, which occurred when we used the loop to cut the adhering adenoma from the surgical capsule. In both cases, the perforation was minimal and did not alter the clinical course or the planned catheter removal. No severe intraoperative or postoperative complications occurred.

PVP is characterized by excellent hemostatic properties and a low intraoperative complication rate,²⁴ even in patients with large prostates who are known to be at a high risk for perioperative complications. PVP has a better safety profile, including shorter catheterization and hospitalization times. However, no patient in our bipolar TUEP group developed TUR syndrome or required blood transfusion, which was comparable to that in the PVP group. There was no significant difference in serum sodium loss or hemoglobin loss in the bipolar TUEP and PVP groups. To the best of our knowledge, there have been no reports of TUR syndrome associated with bipolar TUEP. Furthermore, according to several relevant publications, there have been no substantial changes in the serum sodium postoperatively in patients who undergo bipolar TUEP.^{11,13} One reason for the safety of bipolar TUEP is that the bipolar system provides sufficient hemostasis and uses physiologic saline as the irrigant fluid during resection.²⁵⁻²⁷ Another is that resection with bipolar TUEP occurs at the level of the surgical capsule, so the vessels are opened only once and sealed by the root. The third reason is that, after the bipolar TUEP procedure, there was almost no residual adenoma tissue, resulting in decreased postoperative bleeding. In our bipolar TUEP group, no patients developed acute urinary retention or clot retention after catheter removal.

The average durations for catheterization and hospitalization were longer in this study than that reported from other countries. It perhaps reflects the different catheterization protocols from one country to another.¹¹ In addition, most surgical patients in China choose not to

Table 2: Perioperative results of the two groups

Variable	TUEP (n=39)	PVP (n=42)	P
Operative time (min)	83.59±12.96	89.60±20.18	0.277
Resected tissue (g)	68.11±12.72	-	-
Applied energy (KJ)	-	383.17±150.99	-
Decrease in hemoglobin (g dl ⁻¹)	1.65±0.53	1.57±0.51	0.592
Decrease in sodium (mmol l ⁻¹)	2.53±0.45	2.39±0.47	0.136
Catheter duration (h)	110.00±24.57	55.12±36.00	<0.001
Hospital time (days)	5.82±1.05	3.60±1.78	<0.001

TUEP: transurethral enucleation of prostate; PVP: photoselective vaporization of the prostate

Table 3: Complications of TUEP and PVP

Complication, number (%)	TUEP	PVP	CCS grade	P
Intraoperative complications				
Blood transfusion	0	0	2	-
TUR syndrome	0	0	4	-
Early (<3 months) postoperative complications				
Transient incontinence	2 (5.13)	2 (4.76)	1	1.00
UTI	2 (5.13)	3 (7.14)	2	1.00
OAB-symptoms	1 (2.56)	3 (7.14)	2	0.617
Dysuria	2 (5.13)	5 (11.90)	2	0.434
Retention	0	0	3	-
Urethral stricture	1 (2.56)	2 (4.76)	3	1.00
Late (>3 months) postoperative complications				
Bladder neck contracture	0	0	3	-
Re-operation	0	0	3	-

TUEP: transurethral enucleation of prostate; PVP: photoselective vaporization of the prostate; CCS: the modified Clavien classification system; UTI: urinary tract infection; OAB: overactive bladder

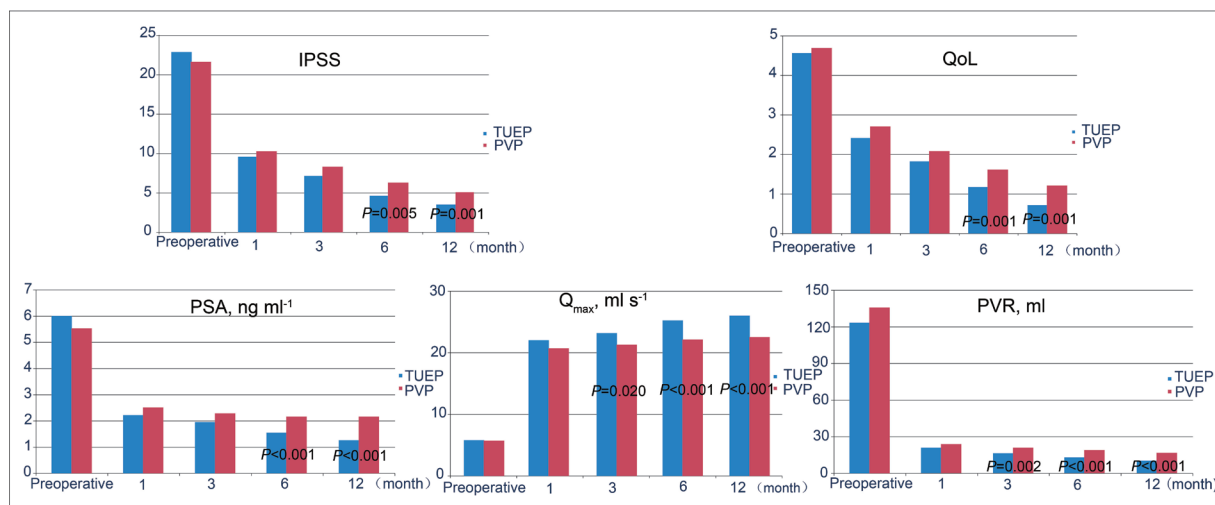


Figure 3: Follow-up data after bipolar TUEP and PVP. TUEP: transurethral enucleation of the prostate; PVP: photoselective vaporization of the prostate.

leave the hospital until they can return to normal activities. Therefore, hospitalization in this study was longer.

When using bipolar TUEP, we are cautious at the apex because the surgical technique is an important factor in risking stress urinary incontinence.^{12,28} We might have left some apical tissue to avoid injury to the external sphincter. Only two patients (5.13%) in the bipolar TUEP group experienced slight incontinence after removing the urethral catheter and were relieved by pelvic floor exercises within 1 month. Two patients in the PVP group experienced incontinence. We found that both bipolar TUEP and PVP groups were similar with respect to the development of stress urinary incontinence.

PSA has long been recognized as a correlate of the amount of adenoma in the prostate and is easier to use than TRUS to determine prostate size.^{29–31} Furthermore, a decreased PSA level correlates directly with the weight of the resected tissue.³² A low postoperative PSA level is a consistent parameter for assessing the completeness of surgical resection and may predict a good long-term outcome.^{33,34} We used PSA instead of TRUS to determine the prostate volume during the follow-up of these patients. The decrease in PSA after bipolar TUEP was marked at the 6-month follow-up ($P < 0.001$). Other subjective and objective variables, including PVR, Q_{max} , QoL, and IPSS, also reflected a significant difference in micturition function achieved with bipolar TUEP during the follow-up. At the endpoint, the PSA decrease in the bipolar TUEP group versus the PVP group was 79.0% versus 60.4% ($P < 0.001$), Q_{max} increased by 352.9% versus 292.5% ($P < 0.001$), PVR decreased by 91.4% versus 87.3% ($P < 0.001$), IPSS improved by 84.7% versus 76.3% ($P = 0.001$), and QoL improved by 83.5% versus 73.5% ($P = 0.001$), respectively. It can be speculated that the more dramatic improvements and outcomes of bipolar TUEP were mostly owing to the fact that, during the course of enucleation, the resectoscope tip was used in a fashion similar to that of the surgeon's index finger during conventional simple open prostatectomy to detach the adenoma from the surgical capsule with excellent intraoperative visibility. It resulted in complete anatomic adenoma enucleation via a minimally invasive approach, whereas it is difficult to discern the plane and reach it when performing PVP.³⁵ For BPH surgery, it is how much is left that is important, as it is for residual remnant adenoma, which would determine the long-term results of transurethral procedures.³³

The surgical capsule can be identified more easily in large glands,^{13,36,37} which makes enucleation easier in large prostates than in small glands. Bipolar TUEP allows anatomic removal of an entire

prostate adenoma of any size,^{12,13} as well as histologic examination in all cases. About 4.8%–10.0% of incidental prostate cancers are diagnosed by TURP,^{1,38} so many cancer patients may be underdiagnosed following PVP because of the lack of tissue for histologic examination.

Dysuria has been accepted as indicating a need for pain medication after treatment.³⁹ Severe dysuria did not appear in either of our groups. Dysuria in this study occurred at a lower, but not significant, rate in the bipolar TUEP group than in the PVP group. Technical inefficiency is the primary cause of dysuria, with the tissue being coagulated instead of vaporized. The volume of coagulated tissue correlates with the degree of dysuria patient experiences.³⁹ During enucleation, the tip of the resectoscope mimics the tip of the surgeon's index finger during open prostatectomy to produce the anatomic plane between the adenoma and the surgical capsule. The loop was used only to cut the connection between the adenoma and prostatic capsule and to coagulate the denuded supply vessels and hemorrhagic spots precisely on the capsule surface. Thus, thermal coagulation on the surgical capsule is reduced to a minimum. This may cause the rate of dysuria after TUEP to be lower than that after TURP. If the surgeon is inexperienced, it is quite common for the patient to develop dysuria after PVP. Thus, there is a correlation between surgical technique, and the amount of coagulation necrosis.⁴⁰ Training should, therefore, be stressed before performing PVP.

The difference in hospital costs makes it difficult to compare the treatment cost in one hospital with that in another. One characteristic of PVP, however, is its single-use fibers, especially in patients with a large prostatic adenoma. The mean energy use in PVP was 383.17 KJ. A total of 26 patients in the PVP group required, at least, two laser fibers to complete the operation, which may increase concerns regarding procedural costs.

Although the follow-up period of this study was relatively short, we were able to assess the perioperative safety and early improvement of subjective and objective voiding parameters for patients with large prostates. Liu *et al.*¹³ carried out a study of bipolar TUEP with a mean 4.3-year follow-up and found sustainable improvement in voiding function during the follow-up. Conclusions about the durability of bipolar TUEP versus PVP for large-volume prostates require an evaluation of more long-term outcomes.

In this study, we reinforced the favorable safety profile of bipolar TUEP and PVP in patients with large prostate volumes. We observed no severe bleeding or TUR syndrome in either group. In addition, improvement of voiding parameters proved durable for a follow-up of 12 months.

Our study had several limitations. It was a nonrandomized study with a relatively small sample size and only a 12-month follow-up. We did not evaluate cost effectiveness or the patients' sexual function. A multi-center prospective randomized study with an extended follow-up is needed in the future to corroborate our findings.

Both bipolar TUEP and 160-W LBO PVP could improve functional outcomes with no severe bleeding or TUR syndrome in patients with BPH >70 ml. Bipolar TUEP offers more complete removal of prostatic adenomas than that with 160-W LBO PVP. Based on our study, the clinical efficacy of bipolar TUEP for treating BPH >70 ml was more durable and favorable than that with 160-W LBO PVP during the 12-month follow-up.

AUTHOR CONTRIBUTIONS

XNM and SJW have been involved in the data interpretation, performed the statistical analysis and drafting the manuscript, JC and ZXH collected the data, XBJ and LYZ have made the study design, LYZ has made the critical review. All authors read and approved the final manuscript.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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