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Surgical Removal of Prostate: New Advances in The Treatment of Benign Prostate Hypertrophy (BPH)-An Updated Review for Surgeons and Anesthesiologists

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Abstract:

Background: Benign prostatic hyperplasia (BPH) is a common condition that leads to lower urinary tract symptoms (LUTS), affecting many men, particularly those over the age of 80. It is characterized by the proliferation of epithelial and stromal cells in the prostate, causing urethral obstruction. The primary causes of BPH include hormonal imbalances, particularly the roles of dihydrotestosterone (DHT) and estrogen. Traditional management strategies include pharmacotherapy and surgical interventions, with transurethral resection of the prostate (TURP) being the gold standard.

Aim: This review aims to evaluate and compare the latest advances in minimally invasive surgical treatments for BPH, focusing on their efficacy, safety, and long-term outcomes. The study also focus on the main role of Anesthesiologists.

Methods: A systematic review of literature from 1993 to 2022 was conducted. Studies were identified through PubMed, Cochrane Library, and other databases using Boolean search strings related to BPH and various surgical treatments. Both clinical trials and observational studies were included to assess the outcomes of different minimally invasive treatments such as prostatic artery embolization (PAE), transurethral needle ablation (TUNA), and others.

Results: Minimally invasive techniques like PAE, TUNA, and laser treatments offer viable alternatives to traditional surgery, especially for patients who are not candidates for standard procedures. PAE has shown significant improvements in symptom relief with fewer side effects and lower costs compared to TURP, though long-term data is still limited. TUNA and other approaches also demonstrate promising outcomes in symptom reduction and patient satisfaction, especially in patients unfit for more invasive surgeries.

Conclusion: Minimally invasive procedures are effective alternatives to traditional surgical methods in managing BPH symptoms, particularly for patients with large prostates or those at high surgical risk. Further studies are needed to determine the long-term efficacy and safety of these interventions.

Keywords: Benign Prostatic Hyperplasia, Prostatic Artery Embolization, Transurethral Needle Ablation, Minimally Invasive Surgery, LUTS, Prostate Treatment, Anesthesiologists.

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Introduction:

Lower urinary tract symptoms (LUTS) constitute a widely prevalent clinical condition, with an estimated prevalence of approximately 70% in men aged over 80 [1]. The predominant etiology of LUTS is benign prostatic hyperplasia (BPH), which is characterized by an increase in the number of epithelial and stromal cells within the prostate's transition zone [1,2]. The development of prostate hypertrophy is influenced by several factors, including cellular aging, hormonal changes, and genetic predispositions, all of which contribute to the compression of the prostatic urethra and subsequent urinary outflow obstruction [3,4]. While dihydrotestosterone (DHT) and estrogens play critical roles in BPH pathophysiology, they represent merely one aspect of a complex etiological framework. The significance of DHT-mediated signaling is underscored by the efficacy of 5-alpha reductase inhibitors, which form the cornerstone of BPH treatment. Recent studies, however, suggest that diminished testosterone levels and elevated estrogen levels may also contribute to chronic prostate inflammation and the development of BPH [5,6]. The urinary symptoms commonly associated with BPH include voiding difficulties, such as urinary urgency (pollakiuria) and increased frequency of both daytime and nocturnal urination (nocturia). Less frequently encountered symptoms include reduced urinary output, painful urination (stranguria), and the sensation of incomplete bladder emptying (tenesmus) [7]. The severity of these symptoms is typically evaluated using several standardized questionnaires, including the International Prostate Symptom Score (IPSS) and quality of life (QoL) measures [8,9]. Research has consistently shown that LUTS have a negative impact on patients' QoL, often with substantial economic consequences [10,11]. The management of symptomatic BPH generally involves a multimodal approach. Initial interventions typically include lifestyle modifications and pharmacotherapy, encompassing alpha-adrenergic antagonists, beta-adrenergic agonists, 5-alpha reductase inhibitors, anticholinergics, phosphodiesterase-5 inhibitors, and phytotherapeutic agents [12]. In certain cases, or when pharmacological treatment fails, surgical options are considered. Surgical treatments include transurethral resection of the prostate (TURP) and open prostatectomy (OP), with TURP being the established gold standard for surgical intervention in LUTS management [13].

In terms of surgical technique, both monopolar TURP (m-TURP) and bipolar TURP (b-TURP) yield comparable outcomes in symptom improvement; however, b-TURP has demonstrated superiority in treating larger prostates (typically >60 g) and is associated with a lower incidence of resection syndrome, also referred to as TUR-syndrome, as well as a reduced risk of postoperative bleeding [14,15]. TUR-syndrome is primarily caused by an electrolyte imbalance due to the absorption of electrolyte-free irrigation fluids used in m-TURP, a complication mitigated by the use of isotonic fluids in b-TURP. Postoperative complications, including erectile dysfunction and retrograde ejaculation, as well as the risks inherent in general anesthesia, have spurred the development of less invasive surgical options. These techniques include prostatic urethral lift (PUL), minimally invasive interventional radiology procedures such as prostatic artery embolization (PAE), transurethral needle ablation (TUNA), transurethral microwave thermotherapy (TUMT), high-intensity focused ultrasound (HIFU), laser therapies, and partial cryoablation. Although these less invasive approaches reduce surgical side effects, they may exhibit reduced efficacy in relieving urethral obstruction [13,16]. The purpose of this review is to critically assess and compare the latest interventional strategies for BPH. These minimally invasive techniques offer a viable alternative for patients who are no longer suitable candidates for medical therapy or who are ineligible for traditional surgical treatments. We conducted a systematic review of the literature published from January 1993 to January 2022, utilizing original research articles, reviews, and case studies retrieved from peer-reviewed journals and public repositories such as PubMed and the Cochrane Library. Our review adheres to the relevant Equator guidelines, including the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Minimally Invasive Devices

- Transurethral Microwave Thermotherapy
- Transurethral Balloon Dilation
- Transurethral Needle Ablation
- Prostatic Stents
- Intersitial Laser Coagulation

Surgical Therapies

- Transurethral Resection of the Prostate
  - By electrocautery
  - By laser coagulation
- Transurethral Vaporization of the Prostate
  - By electrocautery
  - By laser
- Transurethral Incision of the Prostate
- Open Surgical Enucleation

Figure 1: Minimally-Invasive Treatments of BPH.

Minimally-Invasive Treatment for BPH: Clinical Trials Review

We conducted a comprehensive review of pertinent clinical trials regarding minimally invasive treatments for benign prostatic hyperplasia (BPH) as documented in peer-reviewed journals. The research and selection of relevant studies were facilitated through multiple databases, including PubMed, Google Scholar, MEDLINE, and Scopus. Specifically, PubMed was searched using Boolean search strings such as "prostatic artery embolization" AND "benign prostatic hyperplasia OR BPH," "ablation" AND "benign prostatic hyperplasia OR BPH," "microwave thermotherapy" AND "benign prostatic hyperplasia OR BPH," "laser treatment" AND "benign prostatic hyperplasia OR BPH," and "cryoablation" AND "benign prostatic hyperplasia OR BPH." The inclusion criteria focused on original research examining minimally invasive treatments for lower urinary tract symptoms (LUTS) associated with BPH. Of the 53 articles reviewed, 16 were published in the past five years. Our review is registered with INSPLAY under registration number INPLASY2022120004.

Prostatic Artery Embolization (PAE)

Prostatic artery embolization (PAE) has been endorsed by the Society of Interventional Radiology (SIR) as both a safe and effective treatment option for addressing urinary symptoms resulting from BPH [17]. Several clinical trials comparing PAE to transurethral resection of the prostate (TURP) have been conducted, with varying results. Gao et al. (2014) compared PAE to TURP in patients with an International Prostate Symptom Score (IPSS) of ≥7 following unsuccessful medical therapy. The inclusion criteria for this study included a prostate volume of 20–100 mL and a peak flow rate <15 mL/s. Among the 114 patients enrolled, 94.7% of those who underwent PAE experienced successful completion of the procedure, while 5.3% encountered vascular anomalies that precluded the procedure. A significant improvement in both objective and subjective outcomes was observed in both groups after a two-year follow-up. Notably, the TURP group showed superior results in the early postoperative phase (≤ 3 months) [18]. Carnevale et al. (2016) studied PAE versus TURP in a cohort of 30 patients aged over 45 years with an IPSS greater than 19 and prostate volumes between 30 and 90 cm^3. After 12 months, both treatment groups showed significant improvements in IPSS and quality of life (QoL), though prostate volume reduction was more pronounced in the TURP group [19].

Insausti et al. (2020) conducted a randomized non-inferiority trial in 45 patients over 60 years old, demonstrating that PAE resulted in a reduction of LUTS equivalent to TURP at 12 months, with fewer side effects. However, they emphasized the need for long-term follow-up to assess the durability of symptomatic improvements [20]. Abt et al. (2021) explored PAE in patients with LUTS refractory to medical therapy, revealing that patients treated with PAE reported sustained symptom improvement up to 24 months post-procedure, with fewer adverse events compared to TURP. However, 21% of patients required a more invasive treatment within 24 months due to unsatisfactory clinical outcomes [21]. Patel et al. (2021) conducted a retrospective cost-utility analysis involving 164 patients, showing that PAE is a cost-effective alternative to TURP for managing BPH, although the higher reintervention rate in the PAE group nullified its economic advantage over TURP [22]. Historically, PAE was limited to emergency situations, such as massive hematuria, until DeMeritt et al. demonstrated that it could also reduce prostate volume and alleviate LUTS [23]. Several studies have confirmed postprocedural prostate shrinkage and softening after PAE, further supporting its efficacy [24,25]. The procedure involves the use of local anesthesia and femoral access, with the prostatic artery identified via superselective catheterization. Polyvinyl alcohol microspheres are then injected to induce ischemic necrosis of the prostate tissue, resulting in a reduction in prostate volume [18].

PAE offers distinct advantages, particularly in the treatment of larger prostates, as it can be performed on prostates exceeding 80–100 mL, a limitation of TURP. For example, PAE has demonstrated a prostate volume reduction exceeding 44% in prostates with volumes as large as 550 mL [26,27]. Additionally, PAE is economically favorable, as it incurs significantly lower costs than TURP due to the absence of hospitalization and anesthesia costs, amounting to only one-third of the expenses associated with TURP [28]. However, the procedure's success can be hindered by significant vascular abnormalities and severe atherosclerosis [19,29]. Studies have affirmed the safety and efficacy of PAE as a valid alternative for patients who either refuse or are ineligible for conventional surgical treatments like TURP. For instance, Xu et al. confirmed that while TURP yields superior subjective and objective outcomes, PAE is a safe and effective option for managing LUTS due to BPH in such patients [30]. In a comparative study, Gao et al. found that while TURP showed faster early postoperative improvements (within the first three months), the long-term outcomes of both TURP and PAE were comparable, with PAE's benefits becoming more apparent after a longer period due to the gradual histopathological changes following blood supply reduction [18]. Carnevale et al. also demonstrated comparable efficacy between PAE and TURP in reducing IPSS, QoL, and prostate-specific antigen (PSA) levels [19]. However, the absence of significant long-term data on PAE's efficacy limits definitive conclusions regarding its long-term feasibility and efficacy [30].

Transurethral Needle Ablation (TUNA)

Transurethral Needle Ablation (TUNA) is a minimally invasive procedure that utilizes transurethral access to deliver energy, in the form of radio frequencies, to the target prostatic tissue via a monopolar 490 kHz electrode. This method causes intracellular heating ranging from 70°C to 110°C, ultimately leading to tissue necrosis [31,32]. Modern TUNA devices feature dynamic power regulation, enabling real-time monitoring of tissue impedance and temperature to minimize thermal damage to adjacent non-target tissues. Compared to Transurethral Resection of the Prostate (TURP), TUNA offers several advantages, including lower costs, the absence of general anesthesia, and its suitability for patients who are either unfit for surgery or for whom medical therapy is no longer effective or feasible [11,32,33].

Law et al. identified key inclusion criteria for TUNA, including side effects of medical therapy in 19% of patients, patient reluctance to continue chronic medication in 32.2%, and persistent symptoms despite medical therapy in 48.8% of patients. Their study demonstrated significant improvements in urinary symptoms post-TUNA, with a 65% improvement in the International Prostate Symptom Score (IPSS) and a 75% improvement in Quality of Life (QOL) [11]. Multiple controlled studies have compared TUNA with TURP, demonstrating that while TURP is more effective in achieving urethral disruption, TUNA still remains a viable treatment option for BPH patients who are not candidates for more invasive procedures. In a series of clinical trials, patients who underwent TUNA showed promising results, though TURP consistently offered better outcomes, especially in terms of long-term symptom management.

A significant study by Murai et al. (2001) evaluated the effectiveness of TUNA in 93 patients under low-spinal anesthesia. At three and six months post-procedure, 51.3% and 60.2% of patients, respectively, experienced a reduction of over 50% in their IPSS scores when compared to pretreatment levels. This trial concluded that TUNA is both safe and effective for treating symptomatic benign prostatic hyperplasia (BPH) [36]. Zlotta et al. (2003) conducted a study with 188 patients aged 39 to 85 years, with prostate volumes ranging from 20 to 96.9 mL. All patients were treated with TUNA under local anesthesia. The study revealed that 75% of patients did not require further treatment (surgery or medications) over the long term (five years). Additionally, significant improvements were observed in peak flow rate, mean residual volume, and IPSS scores, all of which were statistically significant [33]. Hill et al. (2004) compared the outcomes of TUNA and TURP in 121 patients, with prostate volumes ranging from 20 to 75 mL and an IPSS ≥ 13. The study found that, compared to TURP, TUNA resulted in fewer side effects, including a notable absence of retrograde ejaculation (0% in the TUNA group versus 41% in the TURP group), as well as fewer occurrences of erectile dysfunction, incontinence, and stricture formation. Despite TURP's greater improvement in urinary symptoms within the first four years post-procedure, TUNA proved to be a viable alternative at five years of follow-up [37]. Law et al. (2019) included 121 patients with prostate volumes under 90 cc, an IPSS ≥ 18, and a peak flow rate <15 mL/s. Among these, 62 patients underwent TUNA due to side effects of medical therapy, and 59 patients received TUNA after medical therapy failed. Following the procedure, 43 patients required additional medical therapy, repeated TUNA, or underwent TURP. This study reaffirmed the safety of TUNA, with fewer side effects compared to TURP, though the latter demonstrated greater short-term improvements in urinary symptoms [11].

Transurethral Microwave Therapy (TUMT)

Transurethral Microwave Therapy (TUMT) is a minimally invasive outpatient procedure that has demonstrated efficacy in alleviating urinary symptoms associated with benign prostatic hyperplasia (BPH). This treatment is performed under local anesthesia, with the treatment catheter inserted through the urethra under transabdominal or transrectal ultrasound guidance. The catheter delivers a higher frequency radiofrequency (RF) signal than that used in Transurethral Needle Ablation (TUNA), typically within the range of 915 to 1296 MHz. This RF energy produces electromagnetic radiation with an oscillating magnetic and electric field, leading to the absorption of microwaves by the prostatic tissue. This absorption induces the movement of water molecules within the tissue, releasing energy in the form of heat (45-60°C), which results in coagulative necrosis of the prostate tissue [13]. Modern TUMT catheters have been designed to enhance the focal concentration of microwaves at the prostate, minimizing their dispersion along the catheter. This adjustment reduces the risk of side effects, such as urinary retention, associated with earlier catheter designs [13].

Numerous studies have validated the safety and effectiveness of TUMT, reporting fewer adverse effects when compared to more invasive surgical treatments. However, Hoffman et al. demonstrated that TUMT was less effective than TURP in mitigating lower urinary tract symptoms (LUTS). In their study, the mean International Prostate Symptom Score (IPSS) was 8.2 for the TUMT group, compared to 5 for the TURP group, with the Quality of Life (QoL) improving by 58.7% in the TUMT group and 63.4% in the TURP group [41]. A study by Francisca et al. (2000) randomized 147 patients to receive either high-energy TUMT treatment or TURP. After one year of follow-up, both groups demonstrated significant improvements in QoL, although TURP was found to be more effective [42]. In a comparative study by Djavan et al. (2001), 103 patients aged 45 to 85 years were treated either with terazosin or TUMT. The study found that TUMT had a significantly lower treatment failure rate. At six months of follow-up, patients who received TUMT showed a 35% improvement in IPSS, a 43% improvement in QoL, and a 22% improvement in peak flow rate, compared to the medical treatment group. These improvements were maintained at 18 months, suggesting better long-term clinical outcomes for TUMT, despite the faster onset of action with terazosin [39].

Wagrel et al. (2002) compared TUMT with intraprostatic temperature measurement to TURP in a study involving 154 patients. The improvement in IPSS for the TUMT group was 82% after 12 months, compared to 86% for the TURP group, though this difference was not statistically significant [43]. Hoffman et al. (2012) assessed 540 patients aged 45 and older with prostate volumes between 30 and 100 mL. Of these, 322 underwent TUMT, while 218 underwent TURP. The study concluded that TUMT was less effective than TURP in reducing LUTS. After 12 months, the TUMT group experienced a 65% reduction in urinary symptoms, while the TURP group had a 77% reduction [41]. Further comparisons by Djavan et al. (2001) indicated that TUMT had significantly better long-term results than medical therapy, which had a seven-fold higher failure rate over an 18-month period [39]. Walmsley et al. (13) found that although TURP led to a greater margin of improvement in urinary symptoms, TUMT was associated with a considerably lower incidence of adverse events. Wagrel et al. (2002) noted that while their study provided valuable short-term data on the safety and efficacy of TUMT, limited information is available on its long-term effectiveness beyond 12 months [43].

High-Intensity Focused Ultrasound (HIFU)

High-Intensity Focused Ultrasound (HIFU) represents a non-invasive approach with clinical applications for the thermal ablation of both benign and malignant tissues [44]. Numerous studies have explored the use of HIFU in treating uterine fibroids, palliating pain from bone metastases, and managing prostate cancer and benign prostatic hyperplasia (BPH) [45–47]. In HIFU, frequencies range from 0.8 to 4 MHz, with intensities between 400 and 10,000 W/cm^2, which distinguishes it from conventional diagnostic ultrasound, which typically operates at frequencies between 2 and 15 MHz and intensities of 0.004 to 7.5 W/cm^2. The mechanical waves produced by HIFU are concentrated by specialized transducers at the target tissue site, where the temperature can reach 55°C, causing coagulative necrosis of the affected tissue. To allow for real-time treatment evaluation and monitoring, HIFU can be conducted under either ultrasound (US-HIFU) or magnetic resonance (MR-HIFU) guidance. Hynynen et al. [48] were pioneers in introducing MR-HIFU in their in vivo dog experiments, enhancing both the safety and effectiveness of the technique. Unlike ultrasound guidance, magnetic resonance imaging (MRI) provides superior assessment of soft tissue and more accurate monitoring of temperature in the tissue, although its implementation presents challenges due to the need for MRI-compatible equipment.

Clinical trials have demonstrated the short-term efficacy of HIFU in treating BPH. Bihrle et al. (1994) included 15 patients aged 50 to 80 years with an IPSS of ≥12 and prostate volumes of less than 80 mg. Following HIFU treatment, all patients reported a reduction in their IPSS from an average of 31 (range 22 to 38) pre-treatment to 17 (range 8 to 32) post-treatment, representing a 45.2% improvement at 30 days of follow-up. This improvement continued at 90 days, with the average IPSS decreasing further to 15.8 (range 8 to 31), an overall improvement of 48.4% [49]. Madersbacher et al. (2000) studied 98 patients with prostate volumes ≤75 mL and IPSS ≥18. This study found a 53% reduction in the symptom score, from an average of 19.6 to 8.5 after 12 months of HIFU treatment. However, 43.8% of patients (35 men) required a subsequent TURP procedure during the four-year follow-up due to insufficient therapeutic response [50]. Bihrle et al. [49] observed a 48.4% reduction in IPSS at 90 days, while Madersbacher et al. [50] reported that the improvement in IPSS persisted for up to 12 months, but the long-term follow-up revealed the necessity for TURP in a significant portion of the patients. The primary limitation of HIFU is its difficulty in maintaining precise temperature control due to heat loss, which hinders the proper concentration of the waves and can result in incomplete tissue ablation [44].

Laser Treatments

The side effects associated with Transurethral Resection of the Prostate (TURP) have spurred the development of alternative techniques, such as laser resection. Various types of lasers have been introduced for the transurethral resection of the hypertrophic portions of the peri-urethral prostate, including the Holmium Laser (Holmium Laser Enucleation Prostate, HoLEP), Thulium Laser (Thulium Laser Enucleation Prostate, ThuLEP), KTP/Nd:YAG laser, Nd:YAG laser, diode laser, CO_2 (carbon dioxide) laser, and green light laser [51, 52].

The clinical trials provide an evaluation of the efficacy of different laser treatments. In a two-year randomized trial, Gilling et al. [53] compared HoLEP with TURP in 120 patients, finding similar clinical outcomes in terms of quality of life (QoL) and adverse events, including reoperations and incontinence. Ahyai et al. [54] conducted a study with 200 patients, demonstrating that, after two and three years of follow-up, HoLEP yielded favorable micturition outcomes compared to TURP, with low rates of late complications, suggesting that HoLEP may be a viable alternative to TURP. Mmeje et al. [55], in a retrospective study involving 311 patients, assessed HoLEP outcomes across four age groups, confirming that age does not limit the success of the procedure and does not increase the risk of poor outcomes. Thomas et al. [56] conducted a randomized clinical trial with 269 patients, 136 of whom received GreenLight laser (GL-XPS) treatment, while the remaining 133 underwent TURP. This study showed that GL-XPS treatment was non-inferior to TURP regarding IPSS, adverse events, and reintervention rates at six months. At a two-year follow-up, 83.6% of the GL-XPS patients remained complication-free, compared to 78.9% of TURP patients. Bozzini et al. [57] compared ThuLEP with TURis in 208 patients, reporting that both procedures were effective in reducing urinary symptoms, with comparable operative times. ThuLEP was superior in terms of hemoglobin decrease, catheterization time, irrigation volume, and hospitalization, although there was no significant difference between the two treatments in terms of IPSS and QoL at the three-month follow-up. Tan et al. [58] compared Diode laser treatment to ThuLEP in 205 patients, finding that both techniques resulted in similar operative times, postoperative hospitalization, procedural costs, and complication rates. However, Diode laser treatment demonstrated a shorter catheterization time compared to ThuLEP.

The Nd:YAG laser (neodymium-doped yttrium aluminum garnet) and Holmium laser were among the first laser techniques developed in the 1960s and remain in use today [52]. The laser beam is directed through the end of an endoscope inserted transurethrally, similar to the resectoscope used in TURP. The lasers utilize different wavelengths and frequencies to induce coagulative necrosis in the targeted area. The rate of tissue penetration and thermal effects depend on the absorption of the laser waves by the tissue, with waves that are not absorbed being reflected and potentially causing side effects in adjacent tissues [52].

Laser treatments, particularly HoLEP and ThuLEP, show comparable results to open prostatectomy in terms of decompression and removal of obstruction while providing optimal control of hemostasis [59]. The primary difference between the two methods lies in the type of laser used: the HoLEP employs pulsed wavelengths, whereas ThuLEP uses continuous wavelengths. In a randomized clinical trial, Ahyai et al. [54] compared HoLEP with TURP. Although TURP is still considered the gold standard for the treatment of lower urinary tract symptoms (LUTS), laser resections, such as HoLEP, have demonstrated excellent outcomes in reducing urinary symptoms with fewer side effects than conventional surgery. In a prospective randomized trial, Bozzini et al. [57] compared ThuLEP with TURis, a variant of bipolar TURP that uses saline solution for irrigation, thus reducing the risk of fluid reabsorption syndrome. Both procedures yielded similar results in terms of IPSS and QoL at the three-month follow-up, with ThuLEP showing superior outcomes in terms of blood loss, catheterization time, irrigation volume, and hospitalization duration.

Cryoablation

MRI-guided partial cryoablation has been approved for the treatment of intermediate-risk prostate cancer [60–62]. Selected cases of benign prostatic hyperplasia (BPH) may also benefit from this technique, which presents fewer risks than generalized cryoablation, such as erectile dysfunction, incontinence, and recto-urethral fistulas. This approach targets only the area of the prostate responsible for causing urinary symptoms, offering a more focused treatment option. As of the current literature, published data on the use of focal cryoablation for BPH remains limited, which positions it as a second- or third-line therapy when medical or surgical treatments fail. Two pilot studies have investigated the use of this technique in BPH. In the first study, Ghanouni et al. [63] presented a case report of a patient with BPH who had not responded to medical and surgical therapies and continued to experience unsatisfactory urinary frequency and poor urine stream. Using MRI guidance, focal cryoablation was selectively applied to the pathological area of the prostate. Wang et al. [64] conducted a study on 21 patients with severe BPH and comorbidities, such as cardiopulmonary dysfunction, who were unfit for surgery. These patients underwent focal cryosurgical ablation, and the short-term results were promising, suggesting that focal cryoablation may be a viable option for elderly patients with severe BPH.

Wang et al.'s study utilized ultrasound (US) guidance and demonstrated that focal cryoablation resulted in a significant reduction in prostate-specific antigen (PSA) levels at four weeks and a notable improvement in urinary flow rate (UFR) [64]. In contrast, Ghanouni et al. [63] reported a case in which MRI-guided cryoablation was performed on patients unresponsive to multiple lines of treatment. MRI was used to guide percutaneous access on both sides of the urethra, targeting the hyperplastic transition zones of the prostate. After confirming benignity with biopsies, simultaneous cryoablation was performed on the hyperplastic areas responsible for compressing the urethra. The use of MRI guidance proved superior to US guidance due to its resistance to imaging artifacts that can arise from ice ball formation during the procedure. Although the studies had small sample sizes, and thus modest statistical power, they showed promising results. Both studies reported positive responses in urinary flow, with no complications such as recto-urethral fistulas and improvements in daytime and nocturnal urinary frequency. These findings highlight the potential of MRI-guided focal cryoablation as a promising treatment for patients with BPH who have failed traditional therapies.

Comparison:

As of the current state of medical practice, transurethral resection of the prostate (TURP) remains the gold standard treatment for symptomatic benign prostatic hyperplasia (BPH) in patients who do not adequately respond to medical management. However, TURP is associated with significant adverse effects, including bleeding, retrograde ejaculation, and the occurrence of transurethral resection (TUR) syndrome, which results from excessive absorption of electrolyte-free irrigation fluids [59]. The incidence of TUR syndrome has been mitigated by the adoption of the TUR is technique, which utilizes bipolar energy and isotonic solutions for irrigation, rather than the electrolyte-free solutions used in traditional TURP procedures [14]. Nevertheless, large prostates, particularly those exceeding 80 mL in size, remain a challenge for TURP application [16]. The complications and contraindications associated with TURP have spurred the development of alternative, minimally invasive approaches to treat moderate-to-severe lower urinary tract symptoms (LUTS) secondary to BPH. These alternatives typically provide similar outcomes to TURP in terms of symptom improvement, as assessed by tools such as the International Prostate Symptom Score (IPSS) and quality of life (QoL) assessments. The primary advantages of these minimally invasive procedures include the avoidance of general anesthesia and a reduced incidence of side effects. Additionally, being outpatient-based, they are less invasive and more cost-effective compared to TURP.

One such alternative, prostatic artery embolization (PAE), has shown to be less effective than TURP in the short term, as the shrinkage of the prostate and reduction in obstructive symptoms typically become noticeable only about three months following ischemic damage. However, in the long term, at the 12-month follow-up, PAE's outcomes are comparable to those achieved with TURP [18]. While the body of research on the long-term efficacy of PAE remains limited, a study by Bilhim et al. [65] demonstrated that PAE is a safe and effective option for treating LUTS due to BPH, with a 20% re-intervention rate at five years and 30%–60% after five years. Furthermore, PAE is particularly suitable for treating large prostates, where TURP is not recommended [26]. A key disadvantage of PAE is the potential challenge posed by the tortuosity of the vascular anatomy, which can impair procedural success; however, this limitation may be overcome by using a transradial approach [29].

Radiofrequency-based techniques, such as transurethral needle ablation (TUNA) and transurethral microwave thermotherapy (TUMT), yield faster results than PAE and offer outcomes comparable to TURP by utilizing wave-induced coagulative necrosis. These techniques are capable of removing smaller portions of prostate tissue compared to TURP, resulting in somewhat less effective relief of obstruction but at the cost of a lower complication rate [13,32]. Although there is a lack of long-term data, both TUNA and TUMT have been found to be effective and safe treatments for BPH [40,66].

High-intensity focused ultrasound (HIFU), which employs radiofrequency waves for thermal ablation of prostate tissue, is an area of ongoing investigation. Under either ultrasound (US-HIFU) or magnetic resonance imaging (MR-HIFU) guidance, the precise insertion of the treatment needle into the target tissue can be monitored [48]. However, the difficulty in precisely focusing the waves to reach temperatures sufficient to induce coagulative necrosis continues to limit the efficiency of this technique. Future studies are needed to address issues related to wave dispersion and heat concentration control to improve its efficacy [44]. The application of laser technology in the treatment of LUTS due to BPH has garnered significant interest, particularly with the advent of the Nd:YAG laser and holmium laser (HoLEP). These lasers, with their varied wavelengths and frequencies, induce coagulative necrosis of the hypertrophic prostate zones responsible for urinary symptoms while simultaneously controlling hemostasis, thereby reducing the risk of bleeding [52]. Certain lasers, such as HoLEP, are also suitable for patients on anticoagulant therapy, making them versatile for a broader patient population [57].

Partial cryoablation represents another recent alternative for treating BPH, offering fewer adverse events, such as erectile dysfunction and recto-urethral fistulas, compared to total cryoablation. It also causes less collateral damage to surrounding healthy tissues. Despite these benefits, the technique has not gained widespread popularity due to technical difficulties associated with the thermal beam [63]. In conclusion, the various approaches discussed in this review each present distinct features, advantages, and limitations. It could be argued that the availability of such a wide range of treatment options may lead to variability in clinical decisions and outcomes, with different medical centers relying on their specific expertise, available resources, and trained personnel to determine the most appropriate treatment. While the identification of a universal "gold-standard" approach is tempting, we contend that the diversity of treatment options available will remain a valuable asset in the era of "precision medicine," in which each patient is treated as a unique individual with specific characteristics and treatment needs. Key features of patients that can help clinicians identify the most suitable treatment strategies for BPH are summarized below. These characteristics and exclusion criteria for various minimally invasive treatments are summarized in a table for clarity. The ideal candidates and exclusion criteria for treatments such as TURP, PAE, TUNA, TUMT, laser treatments, and HoLEP are outlined in the following manner:

- **TURP**: Ideal candidates for TURP include those with a prostate volume of less than 80 mL, while it is contraindicated for patients with prostate cancer. Advanced age and anticoagulant therapy pose relative contraindications.
- **PAE**: Suitable for patients with prostate volumes ranging from 30 to 100 mL or more, who are unfit for surgery or general anesthesia. Absolute exclusions include prostate cancer, while poor vascular anatomy and renal dysfunction are relative contraindications.
- **TUNA**: Best suited for patients with a prostate volume of less than 50 g, and for those who are unfit for surgery or general anesthesia. Contraindications include prostate cancer and the presence of cardiac devices or metallic pelvic replacements.
- **TUMT**: Applicable to patients with prostate volumes between 30 and 100 g, though contraindicated for those with prostate or bladder cancer, or large bladder diverticula.
- **Laser Treatments (HoLEP)**: HoLEP is indicated for prostate volumes greater than 90 g, with no age restrictions, and can be performed on patients at high risk of bleeding. Prostate cancer remains an absolute contraindication for this procedure [67].

Role of Anesthesiologist:

The role of an anesthesiologist in the surgical treatment of benign prostatic hyperplasia (BPH) is multifaceted, as they play a critical part in ensuring patient safety and optimizing the outcomes of the procedure. BPH, a condition characterized by the enlargement of the prostate, often requires surgical intervention when conservative treatments, such as pharmacotherapy, fail. Surgical options, such as transurethral resection of the prostate (TURP), are commonly used to alleviate lower urinary tract symptoms (LUTS). While minimally invasive techniques like prostatic artery embolization (PAE) and transurethral needle ablation (TUNA) are gaining traction, the anesthesiologist's role remains central in all surgical approaches to BPH.

Preoperative Assessment and Optimization

The anesthesiologist begins their involvement before the procedure during the preoperative assessment. This phase includes a thorough evaluation of the patient's medical history, physical condition, and laboratory tests. Patients with BPH are often elderly, and many have comorbidities such as cardiovascular disease, diabetes, or obesity, which can influence anesthesia management. The anesthesiologist must assess the risks of anesthesia, including those associated with general anesthesia, regional blocks, and sedation, and determine the best anesthesia approach for the patient. A comprehensive review of medications, particularly anticoagulants or antiplatelet agents, is critical, as these can affect bleeding risk during surgery, especially in TURP where significant bleeding is a concern.

Anesthesia Management During Surgery

The anesthesiologist's role during the surgery itself involves the administration of anesthesia and close monitoring of the patient's physiological status. TURP, the most common surgical approach for BPH, typically requires general or spinal anesthesia. In general anesthesia, the anesthesiologist induces and maintains unconsciousness, ensuring that the patient is comfortable and pain-free throughout the procedure. Spinal anesthesia, an option for some patients, involves the injection of local anesthetics near the spinal cord to provide pain relief while allowing the patient to remain awake or sedated. Minimally invasive procedures like PAE and TUNA, however, may be performed with local anesthesia or sedation, depending on the patient's condition and the complexity of the procedure. For PAE, which involves embolizing the prostate arteries, local anesthesia and conscious sedation are commonly used. This approach minimizes the risks associated with general anesthesia, particularly for elderly patients or those with significant comorbidities.

Intraoperative Monitoring and Risk Management

Regardless of the anesthesia type, the anesthesiologist is responsible for continuous monitoring of vital signs, including blood pressure, heart rate, oxygen levels, and respiratory function. BPH surgeries, particularly TURP, carry risks such as bleeding, fluid overload, and electrolyte imbalances. The anesthesiologist must ensure that the patient remains hemodynamically stable during the procedure and manage any complications that arise. For instance, TURP syndrome, a rare but serious complication involving water intoxication and electrolyte imbalance, requires prompt intervention. The anesthesiologist plays a key role in managing fluid balance and preventing these complications by closely monitoring fluid input and output, particularly in the use of irrigating fluids during surgery.

Postoperative Care and Recovery

Postoperatively, the anesthesiologist is responsible for overseeing the patient's recovery from anesthesia. This includes managing pain, preventing nausea, and monitoring for complications such as respiratory depression or bleeding. The anesthesiologist must also be vigilant for signs of postoperative urinary retention, which can be a concern after prostate surgery. Pain management strategies include the use of analgesics, such as opioids or non-steroidal anti-inflammatory drugs (NSAIDs), as well as regional blocks or nerve blocks if necessary to alleviate discomfort. In summary, the anesthesiologist's role in the surgical removal of the prostate for BPH extends from the preoperative assessment through to postoperative recovery. They are responsible for ensuring the safe administration of anesthesia, monitoring for complications, managing pain, and optimizing patient outcomes. With advancements in minimally invasive techniques like PAE and TUNA, the anesthesiologist's ability to tailor anesthesia plans to the patient's needs is essential for improving the safety and efficacy of these treatments, particularly in high-risk patients.

Conclusion:

Benign prostatic hyperplasia (BPH) remains a prevalent cause of lower urinary tract symptoms (LUTS), significantly affecting the quality of life of elderly men. With the increasing burden of BPH on healthcare systems, there has been a need for advancements in treatment methodologies. While medical therapies are often the first line of treatment, surgical intervention becomes necessary in patients with severe symptoms or those unresponsive to pharmacotherapy. Traditionally, the gold standard surgical treatment for BPH has been transurethral resection of the prostate (TURP). However, its invasive nature and associated risks have prompted the development and adoption of minimally invasive alternatives. Minimally invasive procedures such as prostatic artery embolization (PAE), transurethral needle ablation (TUNA), and various laser therapies have gained prominence due to their effectiveness, lower complication rates, and reduced recovery times. These procedures are particularly beneficial for patients with larger prostates or those with contraindications to traditional surgery. PAE, in particular, has shown to be effective in reducing prostate volume and alleviating LUTS, with fewer adverse events than TURP. Although the long-term data on PAE's efficacy is still under investigation, early results are promising, suggesting it as a viable option for patients with significant prostate enlargement. TUNA has also demonstrated favorable outcomes in patients with moderate BPH, providing substantial relief in symptoms like urinary urgency and frequency. It offers the advantage of being less invasive, requiring only local anesthesia and presenting fewer risks compared to TURP. Moreover, the cost-effectiveness of these procedures, especially PAE, highlights their potential to reduce healthcare expenditures while improving patient outcomes. Despite the advantages of these minimally invasive treatments, it is important to consider the limitations, including their relatively reduced efficacy in large prostates compared to traditional surgery. As such, selecting the appropriate treatment should be based on individual patient characteristics, including prostate size, symptom severity, and comorbid conditions. Future research should focus on refining these technologies, assessing long-term outcomes, and improving patient selection criteria to ensure optimal treatment choices. In conclusion, minimally invasive interventions for BPH are a promising and effective alternative to traditional surgical methods. While they present clear advantages in terms of safety, recovery, and cost, continued clinical trials and follow-up studies are crucial to validate their long-term efficacy and expand their indications. The evolving landscape of BPH treatment promises more tailored, less invasive options for patients, ultimately improving their quality of life.

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إزالة البروستاتا جراحيًا: التقدمات الحديثة في علاج تضخم البروستاتا الحميد - (BPH) مراجعة محدثة لدور كلا من الجراحين وأطباء التخدير

الملخص:

الخلفية: تضخم البروستاتا الحميد (BPH) هو حالة شائعة تؤدي إلى أعراض الجهاز البولي السفلي(LUTS) ، ويؤثر على العديد من الرجال، وخاصة أولئك الذين تتجاوز أعمارهم 80 عامًا. يتميز بتكاثر الخلايا الظهارية واللحمة في البروستاتا، مما يسبب انسداد الإحليل. تشمل الأسباب الرئيسية لـ BPH الاختلالات الهرمونية، خاصة دور ثنائي هيدروتستوستيرون (DHT) والإستروجين. تشمل استراتيجيات الإدارة التقليدية العلاج الدوائي والتدخلات الجراحية، حيث يُعد الاستئصال عبر الإحليل للبروستاتا (TURP) هو المعيار الذهبي.

الهدف: تهدف هذه المراجعة إلى تقييم ومقارنة أحدث التقدمات في العلاجات الجراحية الأقل تدخلاً لـBPH ، مع التركيز على فعاليتها، سلامتها، والنتائج طويلة المدى . ايضاً تركز الدراسة على الدور الهام لأطباء التخدير في عمليات إزالة البروستاتا.

الطرق: تم إجراء مراجعة منهجية للأدبيات من عام 1993 إلى 2022. تم تحديد الدراسات من خلالPubMed ، مكتبة كوكرين، وقواعد بيانات أخرى باستخدام سلاسل البحث البوليانية المتعلقة بـ BPH والعلاجات الجراحية المختلفة. تم تضمين كل من التجارب السريرية والدراسات الملاحظة لتقييم نتائج العلاجات الأقل تدخلاً المختلفة مثل انسداد الشريان البروستاتا(PAE) ، الاستئصال بالإبرة عبر الإحليل(TUNA) ، وغيرها.

النتائج: تقدم التقنيات الأقل تدخلاً مثل PAE و TUNA والعلاجات بالليزر بدائل قابلة للتطبيق للجراحة التقليدية، خاصة للمرضى الذين لا يعتبرون مرشحين للإجراءات القياسية. أظهرت PAE تحسنًا كبيرًا في تخفيف الأعراض مع آثار جانبية أقل وتكاليف أقل مقارنة بـTURP ، على الرغم من أن البيانات طويلة المدى لا تزال محدودة. كما تُظهر TUNA وغيرها من الأساليب نتائج واعدة في تقليل الأعراض ورضا المرضى، خاصة في المرضى الذين لا يستطيعون تحمل الجراحات الأكثر تدخلاً.

الخلاصة: تُعد الإجراءات الأقل تدخلاً بديلاً فعالاً للأساليب الجراحية التقليدية في إدارة أعراضBPH ، خاصة للمرضى الذين يعانون من بروستاتا كبيرة أو الذين يكونون في خطر جراحي مرتفع. هناك حاجة إلى مزيد من الدراسات لتحديد فعالية وسلامة هذه التدخلات على المدى الطويل.

الكلمات الرئيسية: تضخم البروستاتا الحميد، انسداد الشريان البروستاتا، الاستئصال بالإبرة عبر الإحليل، الجراحة الأقل تدخلاً، أعراض الجهاز البولي السفلي، علاج البروستاتا، أطباء التخدير.