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Review

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Interventional therapy in benign conditions of the prostate

Lower urinary tract symptoms (LUTS) is a collective term that sums up the range of symptoms related to problems of the lower urinary tract (bladder, prostate, and urethra). LUTS are most frequently caused by benign prostatic hyperplasia (BPH). About 60% of all men are affected by LUTS during their lifetime and the likelihood increases with age. Up to 50% of men over the age of 50 and up to 80% of men over the age of 80 experience LUTS from BPH. The mean doubling time for prostatic volume (PV) is 32.6 years, with an average growth rate of around 2.2% per year [1]. BPH with LUTS can significantly impair health-related quality of life (QoL) and is linked to erectile dysfunction (ED). Over the past decade, increased modifiable risk factors, such as metabolic disease and obesity, have resulted in an increased incidence of BPH [1]. Consequently, treatment of LUTS in the ageing population is becoming increasingly important, not least from the health economic perspective.

Established therapeutic algorithm

Patient selection

LUTS are broadly grouped into obstructive voiding symptoms, irritative storage symptoms, and post-micturition symptoms. Storage symptoms are twice as common as and more bothersome than voiding symptoms. In individual cases, men may suffer from mainly voiding or mainly storage symptoms, or a combination of both. Voiding or obstructive symptoms comprise hesitancy, weak urinary steam, straining to urinate, dribbling after urination, chronic urinary retention, and overflow incontinence. Storage or irritative symptoms imply urge incontinence, nocturia, and increased urinary frequency [2]. The two most bothersome symptoms are urge incontinence and nocturia [3]. Symptoms are assessed by means of the International Prostate Symptoms Score (IPSS), according to voiding (IPSS-VS) and storage symptoms (IPSS-SS). For diagnosis of the underlying pathology, monitoring, assessing the risk of progression, treatment planning, and prediction of treatment outcomes, guidelines recommend validated symptom score questionnaires, imaging, and functional tests. Therapeutic strategies are nowadays based on the clinical complaint profile, PV, and prostate architecture, as well as on the patient' comorbidities and preferences [2, 4].

In patients with mild symptoms (IPSS 1–7), observation and change of lifestyle (avoiding drinking fluids late at night, reducing alcohol and caffeine, weight loss, and physical activity) are the primary treatment approaches [1]. Even changing the voiding position may improve urodynamic parameters [1]. In case of moderate symptoms (IPSS 8–19), oral medication is recommended, in principle with one of the four agents mentioned in the following as monotherapy or in combination.

Alpha-blockers relax the bladder outlet and the muscles of the prostate gland; they are used to reduce symptoms. However, α-blockers don't arrest prostatic enlargement. 5-Alpha reductase inhibitors (5-αRI) are used to decrease prostate size and reduce the risk of BPH complications such as acute urinary retention (AUR) over time. The combination of these drugs is more effective than either drug alone in reducing BPH-related symptoms [1]. Additionally, the clinical risk of complications is significantly lower with combination therapy compared to 5-αRI monotherapy (reduction by 66 vs. 34% respectively, $p < 0.001$) [5]. Combination treatment is recommended for men with moderate to severe LUTS and an increased risk of disease progression (PV >40 cc) [2]. Both α-blockers and 5-αRI may lead to ED and libido loss, 5-αRI may also lead to gynecomastia. Anticholinergics (antimuscarinics) reduce contraction of the bladder and are used to help with overactive bladder (OAB) as well as storage symptoms. Phosphodiesterase 5 inhibitors (PDE5I) improve IPSS and International Index of Erectile Function (IIEF) scores, but not peak urinary flow (Q_{max}) [2]. Medication is mainly discontinued due to insufficient symptom relief and undesired side effects [2, 6].

According to national and international guidelines, when drug-based management fails, transurethral resection of the prostate (TURP), developed in the 1920s, is the treatment of choice in prostates 30–80 cc. Open prostatectomy (OP) is the surgical technique of choice in prostates >80 cc [2, 4]. TURP, while considered a safe technique with a mortality rate below 0.25%, has a perioperative morbidity rate of up to 20%. The most frequent complications of TURP are ejaculatory disorders such as retrograde ejaculation (RE) in up to 84%; bleeding in up to 20%; transfusion

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requirement in <7%; ED and bladder neck contracture (each up to 10%); urethral strictures (7%); AUR, infections, and sexual impotence (each in up to 5%); and urinary incontinence (UI; in 3%). Although TURP is considered a definite treatment for LUTS, patients who have undergone TURP frequently require retreatment for LUTS during the following 5 years—in up to 14.5% with repeated surgery and in up to 40% with renewed medication [2, 4].

During the past 10 years, laser-based transurethral surgical techniques, particularly holmium laser enucleation of the prostate (HoLEP), have become established as an alternative to TURP due to several benefits: they are applicable in large prostates and are associated with less blood loss as well as shorter periods of catheterization and hospitalization than TURP. HoLEP involves en-block enucleation of the adenoma between the prostate capsule and the enlarged internal gland, and is valued as a particularly anemic operation compared to TURP. Thus, HoLEP has the potential to replace both TURP and OP as a size-independent surgical gold standard for BPH treatment. Unsolved drawbacks of HoLEP are the high incidence of RE in, similar to TURP, 65–90%, transient UI in up to 44%, and the steep learning curve for urologists [7].

Justifiably, urologic management of LUTS secondary to BPH strives for less invasive techniques, to minimize side effects, and to improve patient convalescence [2]. In addition, outpatient procedures and interventions with short hospitalization are desirable. Interventional therapies (IT) are defined as minimally invasive approaches to treat tissue in targeted areas, characteristically without resecting it.

Available interventional technologies

The currently available armamentarium of IT for the treatment of BPH includes mechanical (incision, urethral lift, temporary prostate stent), ablative (steam therapy, aquablation), and endovascular (prostate artery embolization) procedures. However, although IT aim to develop individually tailored treatment options, no conclusive and binding recommendations regarding which IT should be favored for which BPH-associated LUTS currently exist [2, 4, 6, 8–11].

The following paper will introduce the individual IT procedures with the respective principles of operation, respective advantages and limitations, and the current clinical evidence.

Mechanical procedures

Transurethral incision of the prostate

During transurethral incision of the prostate (TUIP), either an electrocautery device or a laser is used to incise the tissue from the bladder neck down to the verumontanum without debulking the prostate. The sectioning of the hypertrophied circumferential tissue allows the bladder outlet to be separated and opened up. TUIP is primarily recommended for small prostates <30 cc and is contraindicated in large median lobes, as this may cause ongoing blockage after incision. TUIP is equivalent to TURP in small prostates regarding IPSS improvement, and superior to TURP in ejaculation preservation; however, the risk of retrograde ejaculation is also increased in TUIP if performed bilaterally. TUIP is recommended by the European Association of Urology (EAU) and American Urological Association (AUA) guidelines for small prostates <30 cc (moderate recommendation, evidence level: grade B) [2, 4, 12].

Prostatic urethral lift

UroLift® (Pleasanton, CA, USA) is a tissue-retracting mechanical device that tightens the obstructing lateral lobes using suture-based permanent implants. The transurethrally delivered nonabsorbable monofilament sutures are placed through to the lateral lobes while kept under traction, enlarging the caliber of the prostatic urethra. After 24 months, UroLift® improves the IPSS from 24.1 to 14 and Q_{max} from 8.4 to 11.3 ml/s. Over 5 years, reintervention due to refractory LUTS is required in 13.6%. UroLift® does not affect the integrity of the bladder neck; therefore, normal antegrade ejaculation is maintained and in the absence of thermal tissue damage, the risk of ED is minimal. To maintain the dorsolateral neurovascular bundle and the dorsal venous plexus, application in the ventral area is carried out between 10 and 14 o'clock in the lithotomy position. UroLift® is recommended by the EAU and the AUA for men with PV <80 cc and the absence of a median lobe who want to maintain antegrade ejaculation (conditional recommendation; evidence level: grade C) [2, 4, 13, 14].

Temporary implantable nitinol device

iTIND® (Olympus, Shinjuku, Tokyo, Japan) is a temporary implantable device composed of three elongated struts with interwined nitinol wires configurated in a tulip shape. The struts are located at the 12, 5, and 7 o'clock positions in order to create defined incisions in the prostate and the bladder neck. An anti-migration anchor is placed cranially to the verumontanum to prevent dislocation. The device is 50 mm long, with an outer diameter of 33 mm, and designed to cover the entire prostatic urethra from the bladder neck to a point just proximal to the external urinary sphincter. Once in situ, the radial force exerted by the self-expanding struts causes ischemic necrosis of the tissue, leading to incision of the bladder neck and prostatic urethra. The device is usually implanted for 5 days, and after this time it is retrievable using a polyester suture attached to the distal end. The rationale of iTIND® is similar to that of TUIP. The 12-month follow-up results in prostates <75 ml are promising: IPSS was reduced from 22.5 ± 5.6 to 8.8 ± 6.4 and Q_{max} increased from 7.3 ± 2.6 to 14.7 ± 8.1 ml/s. After 12 months, no sexual or ejaculatory disorder was reported in previously sexually active patients. Medical retreatment and TURP were each required in 2.4% of the patients. Major advantages of iTIND® are the light sedation required and the short intervention time of 5.8 min on an average. There are no EAU or AUA recommendations for the use of iTIND® [2, 4, 15–18].

Abstract · Zusammenfassung

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Interventional therapy in benign conditions of the prostate

Abstract

Interventional therapies (IT) are increasingly popular treatment options for benign prostatic hyperplasia (BPH). IT aim to reduce morbidity and side effects related to invasive surgical procedures. To date, IT are considered experimental, though they are evolving rapidly and starting to challenge established surgical strategies. With gradually increasing evidence for the benefits of IT in BPH, several techniques are moving out of the realm of research and into everyday clinical practice. As such, IT provides encouraging mid-term functional outcomes with improved health-related quality of life (QoL), particularly in terms of better preservation of ejaculation. The distinct role IT could play as a bridge between exhausted drug-based treatment options and surgery is yet to be defined. Further studies are required before IT can be recommended as alternatives to invasive therapies. Systematic trials are needed to identify subgroups of patients who can benefit particularly from IT in comparison to other treatments, to identify features of the prostate particularly suited to a specific IT, and to analyze the durability of success for each technique.

Keywords

Prostatic Artery Embolization · Quality of life · Lower urinary tract symptoms · Prostatic hyperplasia · Erectile dysfunction

Interventionelle Therapie benigner Erkrankungen der Prostata

Zusammenfassung

Interventionelle Therapien (IT) sind zunehmend gefragte Behandlungsmöglichkeiten der benignen Prostatahyperplasie (BPH). IT zielen darauf ab, die Morbidität und die Nebenwirkungen invasiver chirurgischer Eingriffe zu verringern. Bis heute gelten IT als experimentell, obwohl sie sich rasch weiterentwickeln und teilweise mit den etablierten chirurgischen Strategien konkurrieren. Mit der zunehmenden Evidenz für den Nutzen der IT für die BPH haben bereits mehrere Techniken den Schritt aus der Forschung an die Schwelle der klinischen Praxis geschafft. Als solche liefern die IT mittelfristig ermutigende funktionelle Ergebnisse mit verbesserter gesundheitsbezogener Lebensqualität, v. a. einen besseren Erhalt der Ejakulationsfähigkeit. Die Rolle der IT als Brücke zwischen den ausgeschöpften Optionen medikamentöser Therapien und den operativen Verfahren muss noch definiert werden. Weitere Studien sind nötig, bevor IT als Alternative zu invasiven Therapien empfohlen werden können. Systematische Studien sind erforderlich, um Untergruppen von Patienten zu ermitteln, die im Vergleich zu anderen Behandlungsmethoden besonders von IT profitieren, um Merkmale der Prostata zu identifizieren, die für bestimmte IT besonders geeignet sind, und um die Dauerhaftigkeit des Erfolgs für die einzelnen Verfahren zu analysieren.

Schlüsselwörter

Prostataarterien Embolisation · Lebensqualität · Symptome der unteren Harnwege · Prostatahyperplasie · Erektile Dysfunktion

Ablative procedures

Convective water vapor energy ablation

Rezum® (Boston Scientific, Marlborough, MA, USA) is a thermoablative technique based on the thermodynamic principle of convective energy transfer. Thermal energy stored in water vapor is deployed by transurethral needles that permeate through the prostatic interstitium, disrupting cell membranes and causing prompt cell death and necrosis. Rezum® operate without creating a discernable thermal gradient, reducing the risk of injury to surrounding tissues by dissipated heat. Usually, 1–3 injections are needed for each lateral lobe and 1–2 injections may be delivered into the median lobe. The procedure requires only minimal pain management. Compared to a placebo intervention in a randomized study, Rezum® achieved a 50% IPSS reduction vs. 20% in the control arm. Q_{max} increased by 6.2 ml/s (67%) at 3 months and fell off to 39% at 36 months. The reintervention rate was 4.4% after 3 years. Rezum® bears a low risk of compromising sexual function and appears safe regarding ejaculation preservation. A special feature of Rezum® is that subjects with and without a median lobe had similar improvements in IPSS and urinary flow rate during a 36-month period. The current evidence is based on prostate sizes between 30 and 80 cc. Meanwhile, no EAU recommendations exist for Rezum®. According to the AUA guidelines, Rezum® may be offered to patients with PV <80 cc who desire to preserve ejaculatory function (conditional recommendation, evidence level: grade C; AUA) [2, 4, 19–22].

Aquablation

AquaBeam® (PROCEPT BioRobotics, Redwood Shores, CA, USA) is a non-thermal, hydrojet system exploiting the power of a high-velocity waterjet to dissect prostate tissue. The waterjet is robotically executed under transrectal ultrasound guidance. A single-center study in a non-selected, consecutive patient cohort revealed promising results after 3 months: prostate volume decreased by 65%, IPSS improved from 21.09 ± 6.85 to 7.25 ± 5.2, Q_{max} from 10.75 ± 5.84 to 21.62 ± 12.77 ml/min; 73% of the patients retained antegrade ejaculation, the rate of anejaculation was 10%; no cases of ED were reported. A systematic review revealed that aquablation achieves similar improvements in urologic symptom scores to TURP after 12 months as well as a similar need for reintervention (4.3%). Larger prostates (50–80 cc) demonstrated a more pronounced benefit. Spatial mapping using TRUS allows precise determination of the tissue to be resected, which should reduce the rate of UI and RE. A disadvantage of AquaBeam®, which counteracts the short ablation time of 17–24 min, is that in some cases the wound surface must be coagulated in a second step with a conventional TURP sling in order to minimize secondary bleeding [23]. These conclusions are based on PV of up to 80 cc. There is no EAU recommendation for the use of AquaBeam®. According to the AUA guidelines, AquaBeam® may be offered to patients with PV between 30

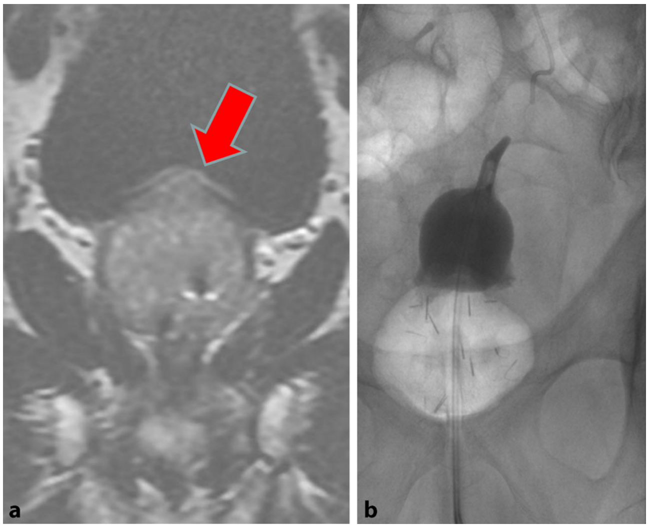

Fig. 1 ▲ A 61-year-old patient with pronounced lower urinary tract symptoms (LUTS; International Prostate Symptoms Score 27), severely impaired quality of life ("very dissatisfied"), and no relevant impairment of erectile function (International Index of Erectile Function 23). The patient desired a treatment that would not interfere with ejaculation; thus, a UroLift® (Pleasanton, CA, USA) was initially performed. One year later, LUTS had not improved and the patient was admitted for prostate artery embolization. **a** Diagnostic MRI (coronal T2-weighted) shows clear protrusion of the prostate into the bladder (intravesical prostate protrusion marked with a *red arrow*). **b** Projection radiography shows the UroLift® anchors in the prostate

and 80 cc (conditional recommendation, evidence level: grade C) [2, 4, 23–25].

Endovascular procedures

Prostate artery embolization

To date, prostate artery embolization (PAE) is the only endovascular treatment for BPH, which is steadily moving from the domain of research and into the everyday clinical setting. In PAE, a highly selective injection of spherical or non-spherical embolic agents into the prostatic arteries is performed under fluoroscopic guidance by interventional radiologists. Cone-beam computed tomography at the time of angiography is used to ensure accurate PAE and reduce nontarget embolization. Numerous systematic reviews and meta-analyses revealed significant improvements in LUTS (up to 13.71) and QoL (up to 2.9), with a low risk of complications in short-, mid-, and long-term follow-up (up to 6.5 years) [11, 26–31]. Clinical and technical success rates were reported as between 76.3 and 100% and 76.7 and 100%, respectively [30]. Fundamental limitations of systematic reviews on PAE are the diversities in patient selection, the use of different embolic materials, different embolization techniques, and, finally, the individual expertise in embolotherapy. As a consequence, we have to deal with an inhomogeneous bulk of meta-analyses. The more important are the few randomized controlled trials (RCT) that exist comparing PAE to other treatments. To date, there are no RCT which compare PAE with medication or a sham procedure or other minimally invasive surgical therapies. Three prospective randomized studies compared PAE with the surgical standard TURP, all three able to conclude decisive statements [32–34]: Gao at al. found that the TURP arm showed faster improvement in terms of IPSS, QoL, Q_{max}, and PVR at 1 and 3 months, but no difference was noted at 6, 12, and 24 months. Carnevale et al. found that TURP and PAE yield similar symptom improvements after 1 year, but TURP was associated with both better urodynamic results and more adverse events. While there was no statistically significant difference in the mean IPSS improvement between the PAE (−9.23) and TURP (−10.77) cohorts at 3 months, the study conducted by Abt and coworkers is the only one to date that assessed subparameters of the IPSS score, e.g., nocturia. In their study, Abt et al. found that nocturia decreased more after PAE than after TURP (by 0.35 versus 0.21 in favor of PAE, $p = 0.68$), and assumed that irritative storage symptoms, which are usually more bothersome to patients, improve less than voiding symptoms after conventional surgery [3, 35]. Summarizing the evidence to date, PAE is efficient in both medium-sized and large prostates, also in asymmetric prostates with unilateral dominance of the enlargement, and also in the presence of a median lobe (▪ **Figs. 1, 2 and 3**). In contrast to many other minimally invasive surgical therapies, PAE is not limited to any maximum PV. PAE does not manipulate the urethra, thereby avoiding urethral stricture or stenosis. PAE is repeatable, if required, and does not exclude a later surgical intervention in case of disease progression. Sexual dysfunction, particularly retrograde ejaculation, has not been reported after PAE. The major asset of PAE is the high degree of satisfaction reported by the majority of patients, attributable to its safety and low side effects rate, without the concern of incontinence, impotence, and retrograde ejaculation [2, 11]. Recent studies demonstrated that predictors of a better clinical outcome after PAE are a younger age (<65 years), a baseline IPSS between 8 and 25, and the presence of AUR [36]. In addition, adenoma-dominant hyperplasias respond better to embolization than stroma-dominant BPH [37]. The currently existing longest follow-up (3–6.5 years) revealed an IPSS improvement of 16.9 points and an improvement in QoL of 1.74, without impacting continence or sexual health [38]. PAE is a technically demanding procedure for the interventional radiologist and requires the necessary experience in embolization therapy in general as well as additional training in PAE in particular. Although PAE has many advantages, it also has some disadvantages. A method-inherent limitation of PAE is the applied radiation exposure. The duration of the radiation depends on the complexity of the pelvic and prostatic vascular anatomy and the degree of atherosclerosis. The median dose–area product is 17.400 μGym². This equates to 44 mSv with a 0.17% additional lifetime

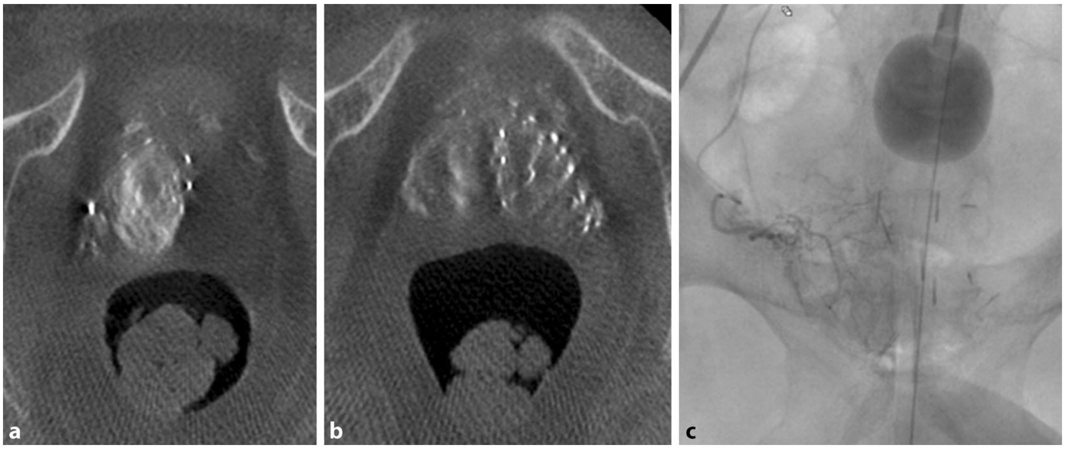

Fig. 2 ▲ Before the actual embolization, pretherapeutic simulation is performed to confirm the optimal position of the microcatheter. Selective contrast-enhanced cone beam computed tomography (CBCT) increases the safety of embolotherapy by excluding contrast outside the target region. **a** CBCT is first performed on one side (e.g., right), then on the other side (left). **b** In the second CBCT, the persistent contrast on the first side can be clearly seen. **c** Embolotherapy is then performed under fluoroscopic control

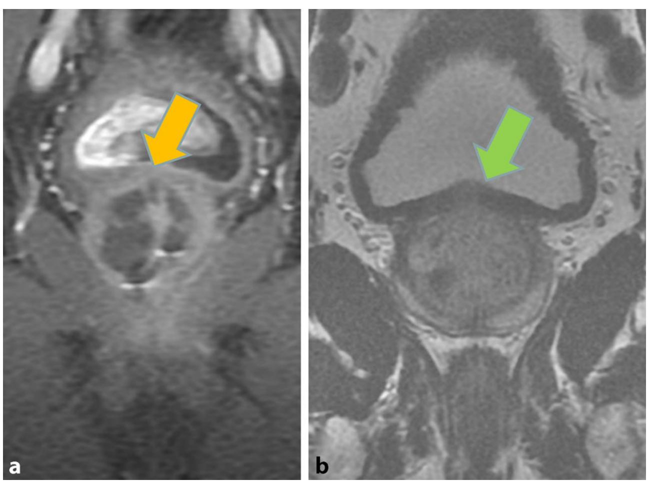

Fig. 3 ▲ **a** In imaging follow-up, devascularization of the embolized areas can be seen after only a few days (*yellow arrow*). **b** In the control after 6 months, almost complete shrinkage of the intravesical prostate protrusion is clearly visible (*green arrow*). Similarly, the leading clinical complaints (urgency from 4 to 1; nocturia from 6–7 to 1) and quality of life ("satisfied") have improved significantly

cancer risk in a 50–59-year-old man [28]. The reduction of radiation exposure is an essential objective of the further development of PAE. PAE is technically limited in patients suffering from severe atherosclerosis, which is why a preinterventional noninvasive assessment of the pelvic vasculature, e.g., with CT or MR angiography, is advised in cases of suspected atherosclerosis [11]. In cases of severe atherosclerosis, transurethral therapies should be considered as potentially more favorable alternatives to PAE. The AUA guidelines do not recommend PAE for the treatment of LUTS attributed to BPH outside the context of clinical trials (expert opinion, defined as a consensus judgement for which there is no evidence) [4]. The EAU recommend a multidisciplinary team approach of urologists and radiologists, in order to integrate PAE into the spectrum of efficient minimally invasive treatment options [2].

For the sake of completeness, it should be mentioned that certain minimally invasive procedures have not made it into clinical routine beyond the proof of principle, such as transurethral microwave (TUMT) and transurethral electrovaporization of the prostate (TUVP) [2, 4]. Furthermore, there is also a negative list of procedures that are not recommended for treatment by the EAU guidelines because of their lack of efficacy or unacceptable side effects. These include transurethral needle ablation (TNA), intraprostatic injection (IPI), and intraprostatic stents. Clinical trials on TNA and IPI have shown no benefit compared to placebo. Permanent prostatic stents are associated with severe side effects and poor tolerability, such as a high migration rate, exacerbation of LUTS, bladder storage symptoms, perineal pain, encrustation, and infection [2].

Discussion

The increasing prevalence of BPH seen in recent decades has been met with a growth of treatment options. According to the current EAU recommendations from 2019, the choice of treatment depends on the findings of patient assessment, the ability of the treatment to change the respective impairing symptoms (instead of "one therapy fits all"), the individual patient's treatment preferences, and the expectations to be met in terms of speed of onset, efficacy, side effects, QoL, and disease progression. The current EAU guidelines clarify that the choice of a surgical technique implies the willingness of the patient to accept anesthesia- and surgery-associated specific side effects [2]. IT are rapidly evolving treatment options for LUTS associated with BPH, with encouraging mid-term functional outcomes, improved health-related QoL, and a better preservation of ejaculation. Gradually reliable evidence on IT for benign prostatic conditions is increasing; nevertheless, their role in the therapeutic algorithm generally is still yet to be precisely defined. More mature evidence based on systematic trials is required to identify subgroups of patients who distinctly benefit from IT in comparison to RT, to identify advantageous or disadvantageous prostate characteristics for a particular IT, to analyze the durability of each technique, and to assess the position of IT as an intermediary between medication and RT.

PAE, the only minimally invasive therapy for BPH that is not performed by urologists but by interventional radiologists, has the status of a cuckoo's egg among the IT. PAE has an established safety and efficacy record and made rapid gains with a still increasing evidence base, and may be a viable treatment for carefully selected patients, pending long-term follow-up data. Special advantages of PAE are the absence of general anesthesia risk, the favorable complication profile without blood loss, the preservation of erectile function, and the absence of retrograde ejaculation. PAE is not a substitute for established surgical procedures for severe obstructions, but rather a bridge between exhausted drug-based treatment options and surgery in patients with moderate to severe symptoms. Furthermore, PAE does not exclude a subsequent surgical intervention in case of disease progression, which is why it should also be seen as a supplement to established therapeutic strategies. As PAE is considered more an interim solution between medication and surgery rather than as an alternative to surgery, the long-term impact on preventing clinical sequelae of BPH, such as AUR, UI, bladder stones, and hydronephrosis, has to be evaluated.

IT have been developed with the aim of decreasing invasiveness, morbidity, and dysfunction related to standard surgical procedures, with a major focus on the preservation of erectile function and antegrade ejaculation. On the other hand, IT should still achieve equivalent clinical results. A core finding of the current evidence is that all minimally invasive techniques are inferior to resection-based techniques in terms of volume reduction and deobstruction. The ranking of Q_{max} improvement, compiled from various studies, is as follows: enucleation, TURP, AquaBeam®, PAE, UroLift®, and Rezum®, the last three obtaining approximately equal results [1, 8, 10, 15, 31, 34].

A major limitation of the evidence available to date is that it is generally evaluated on the basis of the criteria established for classic deobstructive procedures. Above all, the improvement in Q_{max} is in many publications a knockdown argument in favor of radical treatments, even though it is already generally known and scientifically proven that patients with LUTS primarily suffer from storage symptoms, particularly urge incontinence and nocturia. The weak urinary stream, despite its high prevalence, is a less bothersome symptom [3]. Another compelling argument for radical therapies is the reduction of PV; however, as also already confirmed in many studies, reduction of PV does not correlate with relief from LUTS [10]. Surprisingly, as early as 1997, on the basis of the BPH study on the bothersomeness of urinary symptoms, the International Continence Society demanded that when deciding upon treatment, not only the presence and frequency of LUTS, but also the bother they cause should be considered. This demand has not made it into scientific routine even after 23 years [39–41]. Current evidence suggests that, e.g., PAE, has a proportionally greater effect on storage symptoms, including nocturia, than surgical therapies [28, 34, 42]. Nevertheless, PAE is generally classified as being inferior to TURP with regard to the reference values Q_{max} and PV reduction. Therefore, in order to create reliable evidence for the future, it must be demanded that—irrespective of the applied technique—further studies should include a meticulous assessment of clinical parameters that influence QoL, above all urge incontinence, nocturia, the sense of incomplete emptying (not synonymic with post-void residual), and preserved sexuality [42]. As different as the minimally invasive therapies are, as detailed they have to be depicted within the complex complaints of the LUTS.

Nocturia has a special position among the LUTS, not least because it is associated with enormous socioeconomic losses. It is a common and bothersome condition, with two voids per night as a critical threshold. Nocturia is associated with higher levels of sleep disturbance and daytime fatigue, as well as lower life satisfaction, work engagement, and productivity. A recent economic analysis found that nocturia is associated with $ 79 billion lost economic output per year across six countries (US, Japan, Germany, UK, Spain, and Australia), indicating that nocturia is an important concern that requires intervention [43]. An analysis in the EU-15 countries estimated the total annual costs of hospitalization for hip fracture due to severe nocturia to be approximately € 1 billion [44]. Due to the considerable burden of nocturia on QoL and a lack of effective management options, more founded research is needed [2, 4].

Some of the study results indicate that in the future, almost every patient can be offered an individualized surgical technique that provides optimal symptomatic and functional improvement with a minimized risk of complications [6].

Requirements for a personalized treatment strategy are as follows

- Current evidence including recommendations, limitations, and contraindications of the particular procedure.
- Efficacy in relieving the individually leading symptoms.
- Maximum avoidance of irreversible side effects.
- Respect of individual preferences, e.g., preserved sexuality and libido.

For many minimally invasive surgical therapies, the size of the prostate and the presence of a median lobe is crucial (Table 1). General contraindications for IT are prostate and bladder cancer, neurogenic bladder, acute urinary tract infections, and cystolithiasis. Urinary retention is a contraindication for AquaBeam®. Urethral strictures cannot be treated with PAE.

Table 1 Special features of interventional therapies (MIST and PAE) in the treatment of benign prostatic hyperplasia					
Intervention	**Recommendation**	**Anesthesia**	**Limitation**	**Retrograde ejaculation**	**Re-intervention rate (%)**
TUIP	PV ≤30 cc	GA	PV >30 cc, median lobe	18.2%	18.4
UroLift®	PV ≤70 cc	GA/SA or SED	PV >70 cc, median lobe	No RE	13.6
i-TIND®	PV ≤100 cc	SED	PV >100 cc	No RE	4.8
Rezum®	PV ≤80 cc Applicable also for median lobes	GA or SED	PV >80 cc	No RE	4.4
AquaBeam®	PV ≤100 cc	GA	PV >100 cc Large median lobe	27%	4.3
PAE	No upper PV limit Applicable also for median lobes	LA	Severe atherosclerosis	No RE	9

Most MIST have an upper volume limit or are limited by the presence of a median lobe
MIST minimally invasive surgical therapies, *PAE* prostate artery embolization, *PV* prostate volume, *GA* general anesthesia, *SA* spinal anesthesia, *SED* sedation, *LA* local anesthesia *RE* retrograde ejaculation

Ideally, all physicians involved in the assessment should determine consensually which management modality is optimal for the particular patient. Key factors for success of IT generally are knowledge of the specific characteristics of each IT and accurate patient selection based on functional and image-based diagnosis. MRI provides valuable information beyond the exclusion of a malignancy for detailed volumetry of the prostate and analysis of morphological aspects, such as the presence of a median lobe and adenomatous nodules as well as the characteristics of the intravesical prostate protrusion (IPP) and the prostate urethral angle (PUA). In case of planned PAE, analysis of the pelvic vascular anatomy is useful to assess the severity of atherosclerosis and become familiar with the vascular conditions in order to reduce radiation exposure during the intervention. In consideration of the variety of minimally invasive therapies available today, a collaborative effort between urologists, diagnostic radiologists, and interventional radiologists is crucial.

Conclusions for clinical practice

- Due to the variety of current benign prostatic hyperplasia treatment options, targeted patient selection and comprehensive information about all available options is mandatory.
- In addition to the predictive ability of questionnaires and urodynamic measures, prostate imaging is of great clinical importance, specifically for estimating treatment responses.
- Interventional therapies (IT) have been developed with the aim of decreasing invasiveness, morbidity, and dysfunction related to standard surgical procedures, with a major focus on the preservation of erectile function and antegrade ejaculation.
- Both mechanical IT (UroLift® and iTIND®) can be used under local anesthesia or analgosedation. They have a good safety profile and achieve improvement of lower urinary tract symptoms and functional parameters, although the improvement of the latter is less than with transurethral resection of the prostate (TURP). According to previous studies, both erectile function and antegrade ejaculation can be maintained in both procedures.
- Both water-assisted ablation methods (AquaBeam® and Rezum®) can be considered promising. They seem to be suitable for a wide range of patients who can maintain sexual function with a low rate of complications. For an unambiguous evaluation of steam therapy, prospective studies should be awaited to compare it with established standard procedures. There is still a lack of postoperative long-term data for clear evaluation of aquablation.
- Prostate artery embolization (PAE) is an interventional radiologic procedure with high technical success rates and a good safety profile. However, the deobstructive results of PAE are, similar to the mechanical IT and water-based ablation methods mentioned above, inferior to TURP. Current evidence suggests that PAE has a proportionally greater effect on storage symptoms, including nocturia, than surgical therapies. Predictors of a better clinical outcome after PAE are younger age (<65 years), baseline IPSS between 8 and 25, and the presence of acute urinary retention. PAE is not a substitute for established surgical procedures for severe obstructions, but rather a bridge between exhausted drug-based treatment options and surgery in patients with moderate to severe symptoms. PAE does not exclude a later surgical intervention in case of disease progression, which is why it should also be seen as a supplement to established therapeutic strategies.

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Compliance with ethical guidelines

Conflict of interest. A. Kovács declares that he has no competing interests.

For this article, no studies with human participants or animals were performed by any of the authors. All studies performed were in accordance with the ethical standards indicated in each case.

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