Adenomektomy In The Energy Sources Section - From Surgeon's Finger To Laser Energy

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Astract|:The review article presents an existing methods overview of adenomatous tissue enucleation in benign prostatic hyperplasia. A brief development history of both traditional (open adenomectomy) and endoscopic enucleation techniques is presented. Special attention is paid to modern transurethral surgical BPH treatment methods. The features of holmium laser enucleation performing technique of the prostate are considered in detail as one of the most radical modern surgical treatment methods of prostatic hyperplasia. Other laser and non-laser enucleation methods are also covered. It was carried out a comparative analysis of open and endoscopic techniques. The endoscopic adenomectomy term validity has been determined (бу гапни олиб ишлаш керак).

Keywords: endoscopic enucleation, adenomectomy, holmium laser, transurethral resection.

1. INTRODUCTION

Benign prostate hyperplasia (BPH), which is the most common non-neoplastic disease in elderly and senile men, occurs in more than 40% of men over 60 and is the most common cause of lower urinary tract symptoms (LUTS) in men [2].

Over the past decades, the approaches to BPH treatment have undergone significant changes. There are effective drugs, new minimally invasive treatment methods are being developed and new ones are being improved. But even such methods variety does not solve the problem, since in many cases, due to the BPH progression, the need for surgical treatment remains high [10].

The BPH surgical treatment history as such begins in 1884, when Eugene Fuller performed the first suprapubic prostate adenoma excision. In 1890, Peter Freyer reported the first adenomectomy with 5% mortality rate. This operation was called Freyer's adenomectomy and has been the gold standard for BHP for more than half a century.

A century has passed since the open prostate adenomectomy development (OPAE). Naturally, progress did not stand still. During this period, new methods of BPH surgical treatment were mastered, endourological transurethral interventions were widely developed and spread, however, the complications nature remained largely the same [1].

Transurethral resection of the prostate (TUPR) is currently the generally accepted "gold standard" of BPH surgical treatment due to its safety and efficacy, including long-term results [36]. However, complications such as bleeding, hyponatremia, and, less commonly, TURP syndrome (iatrogenic form of water intoxication, a combination of fluid overload and hyponatremia) [12, 13, 39]. These complications can be avoided with bipolar TUPR [14, 19, 25]. Bipolar TUPR allows resection in saline. In this case, the current, in contrast to the monopolar system, does not pass through the body to the skin electrode. The bipolar circuit is

closed at the resection site between the active and return poles, which are fixed in a single block on the resectoscope (true bipolar system) or tube (pseudo-bipolar system). With all the method advantages, long resection times can lead to electrolyte disturbances, which limit the TUPR possibility in patients with a prostate volume more than 80 cm^3.

This limitation was the reason for the search for alternative methods of endoscopic surgical treatment. It is well known that open prostate adenomectomy is a truly radical treatment for patients with BPH. Some authors believe that open surgery is preferable and has more advantages in comparison with endoscopic techniques, as it provides instantaneous and complete removal of the adenoma [11].

The adenomectomy essence consists in blunt separation or the hyperplasia nodes enucleation by the operator's finger from the so-called adenoma false capsule, which ensures radicality. It is this "anatomical enucleation" that is the key criterion for radicalism.

However, for all its radicalism, the OPAE of the prostate is very traumatic and is accompanied by many complications. Therefore, the main progressive direction thought working in the BPH field surgical treatment is the creation and technique implementation that combines the open adenomectomy radicality and the endourological techniques minimally invasiveness. That is, an ideal method creation - endoscopic adenomectomy.

Back in 1983, the term transurethral enucleation of the prostate (TUEP) was introduced. So, Hiraoka Y. [27] described more than 300 TUE cases, in which he separated the adenoma from the false capsule with a blunt blade ("Hiraoka’s knife") or with the resectoscope tip, similar to the way it is done with open adenomectomy. At the same time, the author declares that he did not have a single case of reoperation for recurrent adenoma. The 2016 European Urology Association (EAU) guidelines for non-neurogenic treatment lower urinary tract symptoms caused by BHP introduced the endoscopic enucleation of the prostate (EEP) concept which combines the existing enucleation types [30].

EEP can be divided into 2 types, depending on technique, radical performance or anatomy. One method is blunt transurethral enucleation along the false capsule of the prostate, the so-called anatomical enucleation, which completely removes the adenoma. The second method is transurethral enucleation along the surgical capsule course - i.e. TUPR [27].

In general, however, speaking of anatomical enucleation, we mean the adenoma removal along the false capsule. Endoscopic enucleation can be performed using both laser energy (laser methods) (Table 1) and electrical energy (non-laser methods). The existing EEP methods, in accordance with the European Urology Association recommendations (EAU), include holmium laser enucleation of the prostate (HoLEP), thulium laser enucleation of the prostate (ThuLEP) [18], diode laser enucleation of the prostate (DiLEP) as well as the monopolar techniques and bipolar prostate electroenucleation.

The first holmium laser was used by scientists from New Zealand - Peter Gilling and Mark Fraundorfer. They started working with a holmium laser in 1996 [21], and in 1998 P.J. Gilling, M.R. Fraundorfer [23] presented preliminary results of holmium laser enucleation of prostatic hyperplasia with intravesical morcellation of removed tissue in 14 patients [6]. The morcellator creation and application has become a significant event in the holmium laser use. It was first used in 1996 in the United States and was originally used by gynecologists to remove bulk connective tissue formations from the abdominal cavity. It is thanks? to morcellation, the ability to remove large tissue fragments through a small-diameter canal, that it became possible to create holmium laser enucleation, which changed the approach to the adenoma surgical treatment. This fundamentally new technique has pushed aside the ablation and resection techniques [7,21]. The vaporizing combination, hemostatic capabilities of the holmium laser with transurethral morcellation allows effective surgical treatment of large adenomas with an immediate improvement in urination and a decrease in the number of complications [8].

Table 1. Lasers in BHP treatment: active crystals, wavelengths, techniques [42].

Active crystal	**Abbreviation**	**Radiation wavelength (nm)**	**Methodology**	**Abbreviation**
Holmium	Ho:YAG	2140	Holmium laser ablation of the prostate	HoLAP
			Holmium laser resection of the prostate	HoLRP
			Holmium laser enucleation of the prostate	HoLEP
Neodymium	Nd:YAG	1064	Visual laser ablation of the prostate	VLAP
			Contact laser ablation of the prostate	CLAP
			Interstitial laser coagulation	ILC
Potassium titanyl phosphate	KTP:Nd:YAG (SHG)	532	Photoselective vaporization of the prostate	PVP
Lithium borate	LBO:Nd:YAG (SHG)	532	Photoselective vaporization of the prostate	PVP
Thulium	Tm:YAG	2013	Thulium laser vaporization of the prostate	ThuVAP
			Thulium laser vaporesection of the prostate	ThuVARP
			Thulium laser vapoenucleation of the prostate	ThuVEP
			Thulium laser enucleation of the prostate	ThuLEP
Diode lasers		830	Interstitial laser coagulation	ILC
		940	Vaporization	-
		980	Vaporization	-
			Enucleation	DiLEP
		1318	Vaporization	-
		1470	Vaporization	-

The holmium laser radiation wavelength is 2140 nm (Fig. 1). With holmium enucleation, laser energy with 60-100 W power, concentrated "at the tip" of the laser fiber, allows one to dissect the adenomatous tissue. In this case, the adenomatous nodes are

separated from the capsule in the same way as it is done with the surgeon's index finger during open adenomectomy [1]. The consecutively enucleated middle and lateral lobes are retrogradely displaced into the bladder and subsequently evacuated using a morcellator. In the morcellator using possibility absence, the prostate gland lobes are partially enucleated and then, the devascularized lobes are crushed using a resectoscope and removed along the latter tube (“mushroom” technique). Bleeding vessels coagulation is provided by retraction of the fiber tip 3-4 mm from the vessel. During HoLEP, saline or glycine solution is used as an irrigation fluid [2].

The hemostatic capabilities combination of the holmium laser and transurethral morcellation allows effective treatment even in large adenomas, providing an immediate positive urodynamic effect, as in TUPR, with fewer complications. The initial application of the holmium laser in the BHP treatment was holmium and neodymium Nd: YAG lasers combination - endoscopic laser prostate ablation. The holmium laser was used to vaporize (burn) the canal, after which the hyperplastic tissues were cut off with a neodymium laser. Later, it became possible to vaporize the prostate with only a holmium laser wave, and an electrode with end (side) or end burning was used - the HoLAP technique (holmium laser ablation of the prostate).

In recent years, HoLEP has become more and more popular. HoLEP has several advantages over TPR, especially in patients with large prostate volume [28]. In accordance with the EUA recommendations, for prostate volumes greater than 80 cm^3, HoLEP is the surgery choice along with open adenomectomy and bipolar enucleation [31]. Some authors call HoLEP the new "gold standard" for surgical treatment of prostatic hyperplasia [40]. In addition, today, holmium enucleation of prostate adenoma is positioned as a "size-independent" procedure, i.e. applicable for adenomas of any size [29,41]. Conducted scientific studies confirm the high efficiency of holmium enucleation in eliminating bladder outlet obstruction caused by prostatic hyperplasia. So, Elmansy H.M. [6] reports on positive results of examination of patients even 10 years (62 months) after surgery, including those with large prostate hyperplasia. After HoLEP, in 2004, the bipolar plasmakinetic enucleation of the prostate (PKEP) technique appeared, then later, in the late 2000s, other transurethral, laser-based enucleation techniques were introduced: Tm: YAG (thulium yttrium aluminum garnet laser) vapoenucleation (ThuVEP), transurethral anatomical enucleation with Tm: YAG (thulium enucleation of the prostate - ThuLEP), diode laser enucleation of the prostate (Green DiLEP) and finally green enucleation with Green laser) with lithium borate modulation (LBO).

Many of the proposed laser techniques were rejected at the initial stage of their use as unsuitable for performing enucleation [24].

So, in 2010 T.R. Herrmann with colleagues [25] were the first to propose a technique of enucleation of an adenoma using a thulium laser, similar to holmium, called ThuLEP (thulium laser enucleation of the prostate - thulium laser enucleation of the prostate). If in a holmium laser the radiation is excited by a flash lamp, in a thulium laser the energy is emitted in a continuously generated wave mode. In this case, thulium ions are excited directly by high-power laser diodes. Thanks to? (Due to) the continuously generated laser beam, the thulium laser works better in soft tissues.

The pulsating radiation of the holmium laser produces a bursting effect, while the constantly generated wave of the thulium laser allows the tissue to be smoothly excised and evaporated, achieving excellent hemostasis. Since water is everywhere in soft tissues and is the target chromophore, this creates a constant chromophore content in the tissues irradiated by the laser and leads to a homogeneous interaction of radiation with tissues [26].

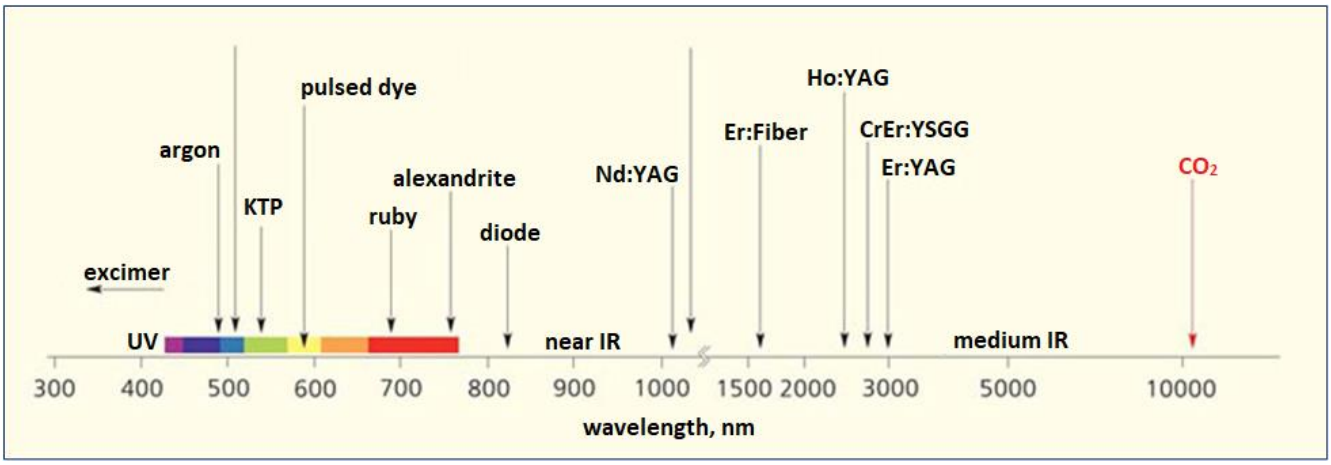

Figure: 1. Lasers used in medical practice, their radiation wavelengths.

As with HoLEP, a large number of studies have been conducted to confirm the ThuLEP effectiveness [5]. Reviewed by Barbalat et al. [15] showed that thulium laser prostate enucleation is a safe and effective procedure. Even before the ThuLEP development, the thulium laser was used to perform prostate vapoenucleation. The ThuVEP procedure was introduced in 2008 for patients with large adenomas.

In general, ThuVEP and ThuLEP - laser technologies "twins" have demonstrated the full spectrum of laser exposure in enucleation techniques. At the same time, while in ThuVEP, the adenoma tissue is first vaporized with long-wave lasers for fast, efficient and safe enucleation, while in ThuLEP, almost blind mechanical enucleation is performed using a laser only for dissecting adhesions and mucous membranes [24].

For obvious reasons, the emergence and such high-tech spread and promising methods, in particular HoLEP, as well as ThuLEP, has led to many publications appearance devoted to assessing the complications after these interventions and their effectiveness. Many centers describe the first experience of using such technologies [8]. The thulium laser use energy to perform enucleation and separation of hyperplastic tissue from the capsule is accompanied by significant carbonization and leads to the fact that the operator tries to minimize the laser energy use and performs mostly mechanical enucleation with a resectoscope.

A number of authors have analyzed the HoLEP effectiveness in comparison with other the prostate treating surgical methods: TPR [17, 20], open adenomectomy [29, 32, 37], endovideosurgical adenomectomy [9], the HoLEP and ThuLEP results were compared [7, 18, 38]. Two large meta-analyzes [33, 34] have compared HoLEP and bipolar enucleation with OPAE. They showed that there was no significant difference between EPE and OPAE in medium- and long-term follow-up. At the same time, HoLEP is characterized by a shorter period of irrigation, catheterization, and hospitalization.

With a large number of factors influencing the choice of the method, in economically developed countries, preference is given to transurethral. In this regard, there are ideas about the futility of using open methods in our country. However, in many countries of the world the traditional surgical treatment of BPH - open adenomectomy - is a priority method, therefore it has the right to exist alongside the latest modern techniques. So, according to Pevzner P.N. [10], the ratio of open and transurethral surgeries of prostatic hyperplasia in certain regions of the Russian Federation (RF), according to different authors, was as follows: according to N.A. Lopatkin in 2002 in Moscow the ratio was 69.4% to 30.6%, in St. Petersburg, according to S.K. Komyakov 64.67% to 35.33%, in Kazan according to E.N. Sitdykov the ratio is categorically rejected in favor of OPAE: 91.31% to 8.69%.

In addition, in the Russian Federation, an alternative method of surgery for treating prostate adenoma is used: extraurethral transvesical and retropubic urethro- and vaso-sparing adenomectomy. A distinctive feature of this technique is the preservation of the dorsal and urethral vascular plexus and the integrity of the prostatic urethra [11].

Comparative analyzes of the BPH surgical treatment results are carried out by various authors haphazardly, often only by listing the complications that have arisen. Most often, any 2 surgical treatment methods are compared: either transurethral (for example, TUPR versus HoLEP) [17, 20], or 2 modifications of any one transurethral method, for example, HoLEP versus ThuLEP [38]. There is no systematic approach to assessing complications arising after open or transurethral interventions in BPH. There are no adequate criteria according to which it would be possible to evaluate each method even at its development stage. Such criteria, in accordance with the Clavien-Dindo classification, have been developed for the endoscopic surgery complications of nephrolithiasis [4].

That is why today the question of studying the surgical complications nature in OPAE, TUPR, HoLEP, their systematization and comparative analysis in relation to each studied methods of surgical treatment, as well as the adequate measures development to eliminate complications, is beginning to play an important role. This is necessary for the most adequate assessment of endoscopic adenomectomies.

Thus, it can be said unequivocally that the future in the BPH surgical treatment is already determined by modern methods of endoscopic enucleation, such as holmium and thulium, as well as bipolar prostate enucleation. However, open adenomectomy cannot be disregarded, since high-tech surgeries, such as HoLEP and ThuLEP, are not yet widespread and in many centers require high-level experience and endoscopic skills.

The radicality of the surgical treatment of BHP lies in the adenoma "anatomical enucleation" within its surgical capsule. And if with OPAE, which provides the best results, enucleation is carried out manually, blindly, then with laser or bipolar enucleation, this procedure is performed under visual control, with the most complete hemostasis. That is, the so-called endoscopic adenomectomy is performed. Enucleation itself is paramount importance, and not the source of energy by which it is carried out, because the ultimate goal in all cases is precisely anatomical enucleation. Endoscopic adenomectomy by laser or non-laser techniques means is confidently leading in the BHP surgical treatment problem and the future lies in the endoscopic methods improvement.

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