Standardization of 532 nm Laser Terminology for Surgery in Benign Prostatic Hyperplasia: A Systematic Review

Micheline D. Stoddard, PhD,¹ Kevin C. Zorn, MD,² Dean Elterman, MD,³ Hannes Cash, MD,⁴ Enrique Rijo, MD,⁵ Vincent Misrai, MD,⁶ Alexis Te, MD,¹ and Bilal Chughtai, MD¹

Abstract

Introduction: The use of GreenLight™ laser technology to remove the prostatic transitional zone transurethally has grown considerably in recent years. This increased utilization has resulted in an increase in the number of terms that are used to describe various laser techniques. Variable terminology complicates literature analysis and publication, which can cause confusion when performing reviews and comparisons of the techniques in the available literature. It has therefore become necessary to simplify and standardize terminology used to describe transurethral prostate debulking procedures using the 532 nm laser to simplify communication on these techniques.

Materials and Methods: We conducted a search on September 17, 2019, in the following databases: Ovid MEDLINE®, Ovid EMBASE, and PubMed.

Results: Of the 1115 unique records found in our database search, a total of 27 articles were selected for inclusion. Of the 16 search terms used, we found that 4 terms could be used to describe the fundamental technique associated with each search term. These terms include “vaporization,” “vaporesection,” “vapoe-nucleation,” and “enucleation.”

Conclusions: Standardizing terminology leads to an efficient consolidation of terms based on the above outcomes. This will streamline the literature search process for future publications and facilitate comparison of varying techniques.

Keywords: enucleation, prostate, terminology, vaporization, vaporesection, 532 nm laser, GreenLight laser, vapoe-nucleation, benign prostatic hyperplasia, laser prostatectomy

Introduction

THE SURGICAL MANAGEMENT of benign prostatic hyperplasia (BPH) has been an ever-changing landscape with a plethora of novel technologies.¹ The use of laser technology to remove the prostatic transitional zone (TZ) transurethally has grown considerably in recent years.² This increased utilization has resulted in an increase in the number of terms that are used to describe various laser techniques. This problem is compounded when the literature includes multiple terms for the same technique. The significant variation in term usage among authors can complicate literature reviews and introduces

challenges in understanding the risks and benefits of various techniques. Therefore, it has become necessary to simplify and standardize the terminology used in 532 nm laser prostatectomy to streamline communication on these techniques.

The GreenLight™ laser system has been of increasing interest to clinicians in recent years given its relative ease of use and versatility. Multiple techniques have been developed using this technology, some of which are similar in practice but described in multiple ways. Given the array of nomenclature observed in the published literature, we sought to standardize language for the variety of techniques used for the 532 nm laser in BPH surgery.

¹Department of Urology, Weill Cornell Medical College/New York Presbyterian, New York, New York.

²Section of Urology, Department of Surgery, University of Montreal Hospital Center, Montreal, Canada.

³University of Toronto—University Health Network, Toronto, Canada.

⁴Department of Urology, Charité University Medicine Berlin, Berlin, Germany.

⁵Department of Urology, Hospital Quiron Barcelona, Barcelona, Spain.

⁶Department of Urology, Clinique Pasteur, Toulouse, France.

Materials and Methods

We conducted a search on September 17, 2019, in the following databases: Ovid MEDLINE®, Ovid EMBASE, and PubMed. Search terms are indicated in Figure 1. A total of 1115 unique articles were identified after filtering for articles that were written in English and studies performed on human subjects (Fig. 2). Two hundred and sixty-one articles were selected for full-text screening after the primary abstract and title screen. Selecting for articles on 532 nm laser prostatectomy with detailed methods enabled us to avoid confusion over nuances among variations on a given technique. Of these 261 articles, 24 unique articles were identified, which met these criteria. Three articles meeting our inclusion criteria that were not identified in our database search were found in the citations of articles that underwent full-text screening. Additional reasons for exclusion at this stage included: article was written in a foreign language despite having an English abstract; the study was based on non-human subjects or performed *in vitro*; the study was out-of-scope (such as articles on the development/characterization of the technology that did not involve clinical data); or the article was a duplicate that had been missed in the primary screen.

Articles included in the study were read by one investigator. The surgical technique described in each article was categorized as vaporization, vaporessection, vapoenucleation, or enucleation, and the article was cited accordingly. If an

article made mention of procedures or variations on techniques not included in our database search (such as the Malek technique and Spiral technique, as indicated in Fig. 1), the variation was described in the Results section and added to Figure 1 for the sake of completeness.

Results

Vaporization

Vaporization, commonly referred as photoselective vaporization of the prostate (PVP) in the literature, refers to the creation of a channel through the prostatic TZ³ (Table 1). Vaporization debulks the prostate by delivering high energy via a 532 nm laser beam that vaporizes the prostate adenoma (Fig. 3A). Laser vaporization is performed by a noncontact delivery of laser energy under direct visualization. The laser fiber is held ~1 to 2 mm from the tissue and used to “paint” the tissue until it is ablated (Fig. 3Aiii). In this technique, the lateral lobes are evenly vaporized until reaching as best possible the capsular fibers. The median lobe is then vaporized to the level of the transverse fibers of the vesical neck.^{4,5} Several articles describe initial removal of the median lobe, followed by the removal of the lateral lobes.^{6–9} Regardless, the appearance of a transurethral resection-like (TUR-like) cavity marks the end of both procedures.¹⁰

FIG. 1. Search terms (*gray boxes*) used in our database search. Based on the procedure described in the full text of qualifying articles, each of these search terms was placed into the “vaporization,” “vaporessection,” “vapoenucleation,” or “enucleation” categories. *Terms marked with an asterisk (*) were identified during analysis of full text and were not used in the initial database search.*

FIG. 2. Schematic of methods for systematic review.

Vaporization includes subtle variations on the standard PVP technique, such as the Malek procedure,¹¹ where the lateral lobes of the prostate are vaporized starting at the bladder neck, followed by the median lobe¹²; the Basel technique, in which a tunnel is made from the bladder neck to the verumontanum through the lateral lobes with the lateral lobes by moving from the 7 and 5 o'clock positions to the 11 and 1 o'clock positions, respectively¹³; and the anterior start technique, in which the prostate is resected from the 11 to 1 o'clock positions from the bladder neck to the verumontanum^{13–16} (Table 1).

Anatomic PVP is a variation on vapoenucleation (see “Vapoenucleation section” below) that treats along the predefined surgical capsule to completely ablate the adenoma^{17,18} (Table 1). Complete vaporization of the prostatic tissue distinguishes anatomic PVP from vapoenucleation, in which prostatic fragments are removed from the bladder at the end of the procedure. Vaporization techniques are more time-intensive than other transurethral debulking techniques, and no tissue is available for pathology.

Vaporessection

Vaporessection techniques were developed to address the limitations of vaporization procedures (Fig. 3B and Table 1). Vaporessection is similar to vaporization in that 532 nm laser energy is used to vaporize the prostatic TZ. However, instead of completely vaporizing the tissue, the adenoma is cut into small pieces by vapomorcellation and mechanically removed at the end of the case^{19–21} (Table 1).

This technique is performed in three steps. Step 1 is to remove the proximal portion of the prostate. An incision at the 7 o'clock position is created and deepened until the laser reaches the surgical capsule. The operating plane is expanded

transversely along the prostatic capsule toward the 5 o'clock pattern and toward the bladder neck to remove the median lobe (Fig. 3Bi). An incision is created in the 9 and 3 o'clock planes on the right and left lateral lobes, respectively (Fig. 3Bi–iii). Vaporization continues along the 12 to 9 o'clock positions and the 12 to 3 o'clock positions to remove the proximal portions of the left and right lateral lobes circumferentially. Step 2 is removal of the distal portion of the prostate. The distal portions of the right and left lateral lobes are removed by vaporization from the 7 to 9 o'clock positions and from the 5 to 3 o'clock positions, respectively (Fig. 3Bii and iii). In Step 3, residual tissues along the surgical capsule are then removed. Before removal of the adenoma from the prostatic wall, the laser tip is inserted into the tissue repeatedly and vaporized into a honeycomb formation. An Ellik evacuator is used to remove the pieces of tissue at the end of the procedure.

This technique is similar to the Spiral technique¹³ in that tissue is removed from the prostate in a circumferential manner, except that the Spiral technique removes tissue in a distal to proximal manner (Table 1). The main benefit of vaporessection is that less heat is transferred to the patient during the resection, which reduces the development of deep layer coagulative necrosis seen in vaporization. This procedure can be used for larger prostate and has the benefit of preserving tissue for histology.

Enucleation

Enucleation, also known as “En bloc” enucleation of the prostate, GLEP, or GreenLEP (green laser enucleation of the prostate “en bloc”), is perhaps the most effective method for removing large amounts of prostatic tissue^{17,22,23} (Fig. 3C and Table 1). A circumferential incision (also known as the

TABLE 1. COMPARISON OF 532 NM LASER SURGICAL TECHNIQUES

<i>Vaporization</i>			<i>Vaporesction</i>		
<i>Technique</i>	<i>Description</i>	<i>Refs</i>	<i>Technique</i>	<i>Description</i>	<i>Refs</i>
PVP	Creation of TUR-like cavity through the prostatic transitional zone.	3–10	PVRP	The proximal portion of the prostate is removed, followed by the distal portion. The adenoma fragment is vaporized into a honeycomb formation before removing the adenoma from the prostate wall. Residual tissues along the surgical capsule are vaporized.	19,21
Malek technique	Lateral lobes vaporized first starting at the bladder neck, followed by the median lobe.	11,12			
Basel technique	Tunnel is made from bladder neck to verumontanum through lateral lobes by vaporizing from the 7 to 11 o'clock positions and from 5 to 1 o'clock positions.	13	Photoselective retrograde stripping-vaporization of the prostate	Uses the LBO laser inside the plasma kinetic resectoscope to improve irrigation and facilitate simultaneous blunt dissection with vaporization.	20
Anterior Start technique	Resection occurs from the 11 to 1 o'clock positions from bladder neck to verumontanum.	13–16	Spiral technique	Similar to PVRP, except distal prostate is removed first, followed by the proximal prostate.	13
Anatomic PVP	Vaporization creates central cavity. Blunt dissection is used to identify interphase between capsule and adenoma. Vaporization is performed laterally and anteriorly along capsular plane.	17,18	Vapor incision technique/ vaporization incision technique	Incisions are created down to surgical capsule. Side-fire vaporization allows for tissue excision rather than vaporization.	
<i>Tissue removal</i>					
Vaporization (no tissue removal needed).			Prostatic fragments can be removed using an Ellik evacuator, forceps, or transurethral loop. Tissue available for pathology.		
<i>Enucleation</i>			<i>Vapoenucleation</i>		
<i>Technique</i>	<i>Description</i>	<i>Refs</i>	<i>Technique</i>	<i>Description</i>	<i>Refs</i>
Transurethral laser enucleation of the prostate and Seoul Technique	Median lobe is resected, followed by the lateral lobes. The cavity is smoothed by vaporizing anterior prostate then removing apical tissue at verumontanum.	24–26	Green laser enucleation of the prostate “en bloc”	A white line is created to mark area between adenoma apex and external sphincter. Blunt dissection removes the adenoma from the surgical capsule from the 7 to 11 o'clock positions. The dissected lobes are pushed into the bladder. The adenoma is morcellated and retrieved. The 532 nm laser is only used for coagulation.	17,22,23
Seoul II technique	Adenoma is removed as described above, except pushed into the bladder while connected to a stalk. Bipolar electrocautery is used to liberate the adenoma fragment from the bladder neck.	27			
<i>Tissue removal</i>					
Prostatic fragments are removed using a morcellator after enucleation. Tissue available for pathology.			Prostatic fragments can be removed using an Ellik evacuator, forceps, or transurethral loop. Tissue available for pathology.		

LBO=lithium triborate; PVP=photoselective vaporization of the prostate; PVRP=photoselective vaporesction of the prostate; TUR-like = transurethral resection-like.

FIG. 3. Diagram of techniques that require vaporization. **(A)** Vaporization. **(i)** Endoscopic view of prostate with enlarged lateral and median lobes. **(ii, iii)** The 532 nm laser is "painted" across the adenoma until the surgical capsule has been reached. **(B)** Vaporessection. **(i)** A vertical incision is lasered into the median lobe, followed by incisions at the 5 and 7 o'clock positions. The median lobe halves are then vaporized into smaller fragments and swept into the bladder by irrigation. Then, an incision is created along the 9 o'clock plane of the right lateral lobe. **(ii)** The right lateral lobe is vaporized from the 12 to 9 o'clock positions and from the 7 to 9 o'clock positions, respectively. Fragments of the right lateral lobe are swept into the bladder by irrigation (white arrow). An incision is made along the 3 o'clock plane of the left lateral lobe. **(iii)** The left lateral lobe is vaporized in similar manner. Prostatic tissue fragments are removed at the end of the procedure with an Ellik evacuator or by draining. **(C)** Enucleation. **(i, ii)** A "white line" is vaporized circumferentially around the prostate. The right lateral lobe is then dissected away from the surgical capsule en block and pushed into the bladder (black arrows). The left lateral lobe is similarly dissected. **(iii)** The median lobe is then dissected and pushed into the bladder. The prostatic fragments are removed from the bladder with a morcellator. The 532 nm laser is used only for coagulation.

"white line"^{17,23}) is created to mark the limit between the apex of the adenoma and the external sphincter, taking care to preserve the crista urethralis. The median lobe is dissected from the prostatic capsule using blunt mechanical energy until it has been pushed into the bladder (Fig. 3Ci). Deep dissection of the right lateral lobe begins at the 7 o'clock position until the capsular plane is identified (Fig. 3Cii). Mechanical energy is used to dissect the adenoma from the surgical capsule until the adenoma is pushed into the bladder at the 11 o'clock position.^{17,23} This is repeated on the left lateral lobe until the adenoma is pushed into the bladder at the 1 o'clock position (Fig. 3Ciii). The adenoma is then

morcellated using a commercially available morcellator coupled with an offset nephroscope. In addition to expedited removal of larger prostates, this procedure also has the advantage of preserving tissue for pathology.

Vapoenucleation

Vapoenucleation, also known as transurethral laser enucleation of the prostate (TLEP)^{24,25} (and later published as the Seoul technique [ST]²⁶), describes a generalized three-step technique for laser prostatectomy²⁴⁻²⁶ (Fig. 4 and Table 1). First, the median lobe is resected. A vertical

FIG. 4. Diagram of vapoenucleation. (A) A vertical incision is lasered into the median lobe, followed by incisions at the 5 and 7 o'clock positions. (B) The median lobe halves are then vaporized into smaller fragments and swept into the bladder by irrigation. (C) An incision is made on the right lateral lobe from the 12 to 10 o'clock positions and from the 7 to 9 o'clock positions. The adenoma is vaporized into smaller pieces and swept into the bladder (white arrow). (D) An incision is made on the left lateral lobe from the 12 to 2 o'clock positions and from 5 to 3 o'clock positions. The adenoma is vaporized into smaller pieces and swept into the bladder (white arrow). (E) The channel is smoothed using the 532 nm laser to ensure that all the adenomas have been removed.

incision is made, followed by two incisions at the 5 and 7 o'clock positions (Fig. 4A). The two median lobe halves are connected to the prostatic capsule by a stalk and removed by slicing sections off of the adenoma with the 532 nm laser (Fig. 4B). Step 2 is dissection of the lateral lobes. A line is made from the roof of the prostatic urethra and protruding from the right lateral lobe at the 11 o'clock position²⁴ (also known as the "S-point"²⁶) to the level of the verumontanum, which serves as the upper margin for lateral lobe resection. The right lateral lobe is then dissected en bloc until the groove at the floor of the prostate is reached,²⁴ vaporized into smaller fragments, and pushed into the bladder (Fig. 4C). This is repeated to resect the left lateral lobe starting at the 1 o'clock position. They are removed at the end of the procedure using an Ellik evacuator²⁴ or by draining the pieces through the sheath at the end of the procedure.²⁶ Step 3 is to

smooth the cavity to prevent protruding/remnant tissues from interfering with urine flow²⁶ (Fig. 4E). This is carried out by vaporizing the anterior prostate and then removing apical prostatic tissue at the verumontanum.²⁴

A variation on this technique (termed the "Seoul II technique" by the authors) was recently described in which both the 532 nm laser and a bipolar electrocautery instrument were used²⁷ (Table 1). Vapoenucleation with the 532 nm laser progressed to the point where the enucleated tissue was connected to the bladder neck with a stalk. The laser was then removed and a bipolar device introduced to resect the tissue still connected to the bladder neck.²⁷ This technique also preserves prostatic tissue for pathology.

Conclusions

We introduced these standard terminologies to help lead to more accurate grouping of 532 nm laser prostatectomy outcomes for easier reporting and analytics. Each technique differs in the direction of laser energy, the use of additional technologies (such as the morcellator), and the preservation of tissue for pathology. Some of these techniques build upon one another, giving surgeons the ability to perfect their skills with techniques, such as vaporization (which has a shorter learning curve), and then progress to more advanced techniques, such as vapoenucleation, when they are more experienced. For patients who require resection of a large prostate in a minimal amount of time, enucleation remains the most efficient technique with durability comparable to that of holmium laser enucleation of the prostate.²⁸ By standardizing terminology, researchers will be able to directly compare various techniques for safety, efficacy, and durability.

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Address correspondence to:

Bilal Chughtai, MD

Weill Cornell Medicine

Department of Urology

Department of Obstetrics and Gynecology

425 East 61st Street, 12th Floor

New York, NY 10065

E-mail: bic9008@med.cornell.edu

Abbreviations Used

BPH = benign prostatic hyperplasia
 GreenLEP = green laser enucleation of the prostate
 “en bloc”
 LBO = lithium triboroate
 PVP = photoselective vaporization of the prostate
 PVRP = photoselective vaporesction of the prostate
 ST = Seoul technique
 TLEP = transurethral laser enucleation of the prostate
 TUR-like = transurethral resection-like
 TZ = transitional zone