Clinics in Surgery

Research Article
Published: 11 Feb, 2021

Endoscopic Holmium Laser Enucleation of the Prostate (HoLEP) in the Human Cadaver: Realism and Feasibility

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Abstract

Introduction: The Endoscopic Holmium Laser Enucleation of the Prostate (HoLEP) technique is efficient but requires experience, learning curve and relevant endoscopic skills. There are several devices available for HoLEP technique training, but Human Cadaver (HC) has never been tested in this purpose. The aim of this study was to evaluate the realism and the feasibility of the HoLEP in a HC.

Material and Methods: Fresh male HC were chosen at the anatomy laboratory and were prepared for a three-lobe HoLEP technique. The HC were placed in the lithotomy position with knees extended. The surgical interventions were performed by fellow surgeons supervised by expert surgeons. The model and the surgical intervention were globally evaluated after each procedure. The fellows were asked about the realism and the quality of each step of the surgery.

Results: Sixteen HC were operated by 21 fellow surgeons. The endoscopic anatomical landmarks were well-preserved in all subjects. The absence of bleeding facilitated the vision of the operative field. Endoscope and instruments movements into the prostatic urethra were not modified by the cadaveric rigidity. Prostatic enucleation and intravesical morcellation were able to be fully performed without bladder injury.

Conclusion: This study has shown that the human cadaver could be used as a training model for the HoLEP technique and could become part of the educational arsenal.

Keywords: Benign prostate hyperplasia; Holmium laser enucleation of the prostate; Human cadaver; Learning curve; Minimally invasive surgery; Resident education

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Received Date: *15 Jan 2021*
Accepted Date*: 04 Feb 2021*
Published Date*: 11 Feb 2021*

Citation:
Fassi-Fehri H, Matillon X, Ye H, Badet L, Codas-Duarte R. Endoscopic Holmium Laser Enucleation of the Prostate (HoLEP) in the Human Cadaver: Realism and Feasibility. Clin Surg. 2021; 6: 3069.

Introduction

Transurethral resections of the prostate and open prostatectomy are regarded as the reference surgical treatments for Lower Urinary Tract Symptoms (LUTS) caused by Benign Prostatic Hyperplasia (BPH) [1]. However, since the mid-'90s, new minimally invasive techniques using laser technology have been developed to treat BPH [2,3]. Holmium Laser Enucleation of the Prostate (HoLEP) was initially described by Gilling in the end of the 1990s [4]. Many studies have shown comparable functional improvement to traditional techniques with benefits in terms of duration of catheterization and hospitalization, as well as blood loss [5,6]. As such, the HoLEP technique could be regarded as a new 'gold standard' in the treatment of BPH [7]. Nevertheless, the more frequent complications in the early stages of training combined with a long and difficult individual learning curve are an obstacle to the diffusion of the technique [8]. According to the experts, the number of surgical interventions required to master the technique can vary between 20 and 50 patients [9-11]. There are few validated educational tools that accelerate surgeons' training in the technique and that reduce the learning period at a time when the economic, legal and educational constraints are increasing [12-14]. Human cadavers are traditionally used by anatomists to teach anatomy to students during medical studies. They are also used by surgical teams to improve their anatomical expertise and their surgical practice, and to test or evaluate the feasibility of new techniques or approaches in many medical fields. In urology, several studies have reported the use of the human cadaver to evaluate new approaches and new tools for radical prostatectomy, such as transurethral resection techniques (NOTES) [15], robot-assisted laparoscopic surgery, and single-port laparoscopic surgery, which can be robot assisted or not [16]. Furthermore, the human cadaver

Figure 1: Position of the human cadaver.

Figure 2: Placement of the equipment under surgical intervention conditions.

has demonstrated its value when used for teaching endourological techniques [17]. However, and strangely, no study to date has reported on or evaluated the use of the human cadaver as a teaching model for the endoscopic Holmium Laser Enucleation of the Prostate (HoLEP) technique for the treatment of BPH. The aim of this study was to evaluate the realism and the feasibility of the HoLEP technique in a human cadaver for educational purposes.

Materials and Methods

Cadaveric simulator preparation

Male human cadavers with no history of prostatic surgery or prostate cancer were chosen at the anatomy laboratory in collaboration with the faculty of medicine's school of surgery to perform a three-lobe HoLEP according to the technique initially described by Gilling [4], or a two-lobe technique when there were no median lobe. Digital-rectal examination was performed to assess prostate volume. The subjects were embalmed with bromopol. They had been deceased for less than one month. All the chosen subjects had undergone hepatitis B, C, HIV and Human T-cell Lymphotropic Virus (HTLV 1 and 2) serological testing. The subjects were placed in the lithotomy position (Figure 1). The equipment included a 24.5 Fr. resectoscope, a fiber guide with trigger, a reusable 550 µ laser fiber, a Holmium laser generator set to 80 W and a morcellator (Figure 2). Continuous endoscopic irrigation with water was maintained during the enucleation and the morcellation phase.

Training program

The training program was proposed to fellow surgeons in their final year who were then enrolled in this study. All the participants were inexperienced in HoLEP technique but experienced in other endoscopic procedures. Theoretical lessons on the stages of the technique associated with video presentations of enucleation were added to the technical background for the hands-on-training course. During the first part of the course, the pathology and the surgical aspects of the treatment were described, with a special focus on enucleation techniques. These were followed by alive surgery performed by the expert surgeons. During the procedure, each step was explained and described in detail. During the second part of the training, after a brief course on the embalmed cadavers, the fellows were associated with one expert. The expert surgeon explained and demonstrated the steps of the procedure. The steps of the simulation consisted of: [1] Description of the material and instruments: resectoscope and morcellator, [2] advancing the resectoscope inside the urethra, [3] visualizing of anatomical landmarks and enucleation plan, [4] enucleation of all lobes, [5] bleeding control, [6] intra vesical morcellation. The surgical interventions were performed by fellow surgeons supervised by one expert surgeon. The model and the surgical intervention were globally evaluated after each procedure. The fellows were asked about the realism and the quality of each step of the surgery.

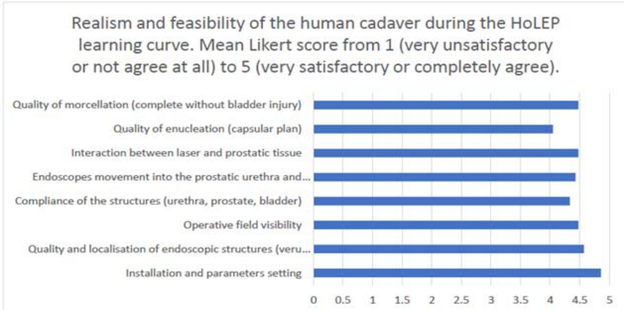

Figure 3: Realism and feasibility of the human cadaver during the HoLEP learning curve. Mean Likert score from 1 (very unsatisfactory or not agree at all) to 5 (very satisfactory or completely agree).

Results

Sixteen human cadavers were operated by 21 fellow surgeons under the supervision of an expert surgeon. Attending both the theoretical and the hands-on-training sections was required. The endoscopic anatomical landmarks were preserved in all subjects (Figure 3): the urethra, verumontanum, sphincter, prostatic urethra, ureteral orifices and bladder were easily visualized. The absence of bleeding facilitated the visualization of the surgical field (Figure 4).

Both the introduction of the endoscopes in the prostatic urethra and instrument manipulation were feasible in all cases, corresponding to real-life conditions. Prostatic nucleation and intravesical morcellation were able to be fully performed without bladder injury in all cases, except one, due to a distal urethral stenosis preventing cystoscope introduction. The model's educational value for performing HoLEP was regarded as very satisfactory by the majority of participants. The results of this evaluation are presented in Figure 5.

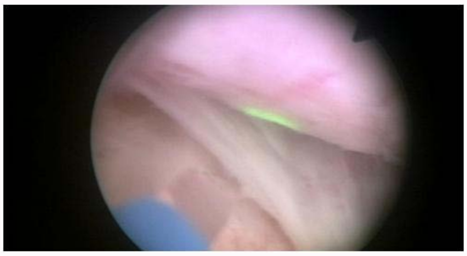

Figure 4: Endoscopic view during enucleation.

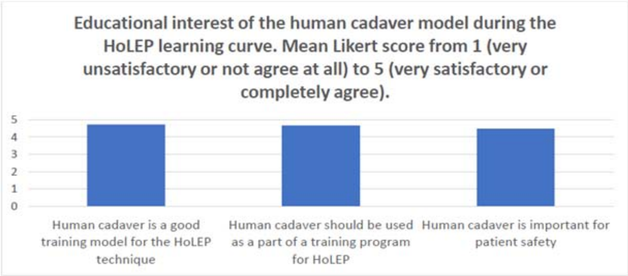

Figure 5: Educational interest of the human cadaver model during the HoLEP learning curve. Mean Likert score from 1 (very unsatisfactory or not agree at all) to 5 (very satisfactory or completely agree).

Discussion

HoLEP is a validated and standardized technique. Whether the three-lobe (two-lobe in the absence of a median lobe) or the en-bloc [18] technique is performed, it requires specific equipment and adapted instrument manipulation that is very different from a conventional transurethral resection [19] or an open prostatectomy. As shown by Shah et al. [20], there is an increased risk of perioperative complications in the early stages of training. However, serious complications during enucleation [21] and morcellation have also been reported. Shigemura et al. [22] showed that, in a cohort of more than 1,000 patients undergoing HoLEP in several centers by surgeons of varying experience, the time of enucleation, the occurrence of postoperative urinary incontinence and postoperative complications were significantly higher in the early stages of training. These results underline the need for rapid mastery of each step of the technique. Greater prostatic volumes lengthen the learning curve [23]. This learning curve is also made longer and more difficult by the fact that there are few patients to treat and thus extended periods of time between each treatment [24]. These difficulties explain why some surgical teams are forced to concentrate technical expertise in the hands of only a few surgeons [25]. There are other explanations to the limited diffusion of the technique: i) the investment cost of expensive equipment, ii) the absence of clear recommendations from academic societies regarding a concrete training program for this technique iii) the problem of fellow training in centers which do not perform this technique, and iv) the lack of availability of expert surgeons to teach the technique [26]. To accelerate the learning curve and improve technical abilities, virtual simulators have also been developed and validated for several urological interventions, particularly for coelioscopic and robotic surgery. Some virtual simulators have also been developed and validated for transurethral resection of the prostate and prostatic photo vaporization with the Green Light laser. The UroSim™ simulator offers a HoLEP technique training program with progressive levels of difficulty and ways to evaluate progress made. The use of this virtual simulator allows trainees to familiarize themselves with the HoLEP technique, particularly during the initial learning curve. It can be integrated into the training course as a complement to physical simulators [27]. Alongside these virtual and physical simulators, enucleation-assistant prototypes in the form of robot-assisted concentric tubes have been developed but have not yet been validated [28]. However, despite their advantages, these simulators cannot replace surgical teaching under real conditions and are still not widely available. Conversely, the advantage of the human cadaver is that it has anatomical structures that are identical to those of patients. Moreover, modern techniques to preserve human cadavers mean that tissues remain in good condition and can be reused for several dissection courses [29]. In urology, several studies have demonstrated the value of human cadavers as a training tool for upper urinary tract endoscopic techniques. Although not validated for prostatic surgery, the use of human cadavers as a training tool for laparoscopic surgery and robot-assisted surgery has also demonstrated its value compared to other tools. In this study, it was possible to perform HoLEP on the human cadaver in all cases except one. To the best of our knowledge, it is the first reported experience using human cadavers for surgical training in this technique. This model allowed a prostatic enucleation surgical intervention to be simulated in the operating theatre: positioning of the subject, knowledge of the equipment, and endoscope and laser generator setting. From a technical point of view, the manipulation of the endoscope in a prostatic urethra and human bladder allowed the training program participants i) to reproduce the instrument manipulation specific to endoscopic enucleation, ii) to recognize and follow the enucleation plan and iii) to learn how to morcellate the enucleation product while following the safety instructions. After the course, the participants recognized the real educational value of this type of model. Nevertheless, there are some technical limits and organizational imperatives. The absence of bleeding means that the training program participant cannot tackle the difficulties of enucleation and morcellation during prostatic bleeding. This problem could be overcome in the future with perfusion and ventilation systems for fresh human cadavers, allowing pulsatile circulation to be restored to the organs (SimLife®) [30]. The shortage of male human cadavers with BPH and with no previous history of prostatic surgery, and the impossibility of performing more than one HoLEP per human cadaver reduce, ipso facto, the availability of this training model. Moreover, unlike virtual simulators, this model does not allow the choice of difficulty levels to evaluate the progression of trainees. Nevertheless, applying the HoLEP technique in the human cadaver could be integrated in a pedagogical course before implementation in the clinical setting (figure 6), which is the main issue. The educational value of this model should be evaluated and standardized before its generalization. Schools of surgery have to be developed in order to generalize this type of training for trainees in their final year. Another solution could be the creation of specific master classes on the HOLEP

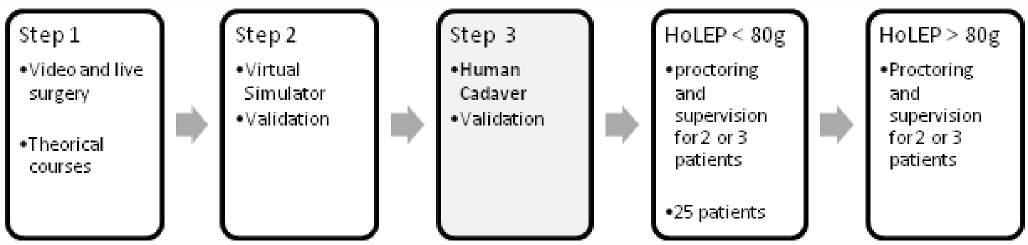

Figure 6: Training program for HoLEP technique.

technique including a first part on human cadavers and a second part with living patients. Finally, a close collaboration between urology departments, the anatomy laboratory and the surgical school, as well as with industrial partners, is vital for the organization and smooth roll-out of training programs using this type of model.

Conclusion

This study has shown that the human cadaver could be used as a training and development model for the HoLEP technique and could become part of the educational arsenal. Nevertheless, further studies are necessary to compare the value of this model to virtual and physical simulators, and to examine its real consequences on the acquisition of technical skills and on the learning curve.

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