ORIGINAL ARTICLE

Onset of a training program for single-port laparoscopic urology☆

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KEYWORDS
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Laparoscopy;
Teaching;
Medical education

Abstract
Objectives: To describe the onset of a single port laparoendoscopic program to carry out oncology surgery in a Urology Service. We present the initial experience in the laboratory and in the Animal Facility with rigid precurved instruments and KeyPort reusable access element (Richard Wolf).

Materials and methods: Two surgeons experienced in laparoscopic surgery and with the help of four assistants performed a training program based on predetermined tasks performed in simulation boxes (pelvitrainer) and porcine model following the requirements of the Regional Community of Madrid to handle experimental animals.

Results: The participants in this program were initially divided into pairs made up of an experienced surgeon and assistant for the predetermined multiple tasks in simulator box in order to become familiarized with the instruments. Then, 20 animal sessions were conducted in which the following were performed: (retroperitoneal or pelvic) lymph node dissections (n = 20), nephrectomies (n = 40), cystorrhaphy with suture (n = 20) and uterine-vesical anastomosis (n = 20). Time needed to perform the exercises and the principal errors perceived during the performance of each one of the tasks were recorded. The tasks, of growing complexity, were performed with the instruments described in increasingly less time and with less difficulty. An accessory trocar of 3.5 mm was required to perform the in vivo sutures.

Conclusions: The KeyPort approach has potential application in different urological applications. Standardized training allows the acquisition of skills and makes the successful implementation of a laparoendoscopic surgery program in humans possible.

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PALABRAS CLAVE
Puerto único;
Laparoscopia;
Enseñanza;
Educación médica

Puesta en marcha de un programa de entrenamiento para laparoscopía urológica por puerto único

Resumen
Objetivos: Describir el inicio de un programa de laparoendoscopia a través de puerto único para llevar a cabo la cirugía oncológica de un Servicio de Urología. Presentamos la experiencia

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Introduction

There was a major change in the past 3 decades in the treatment of different pathologies with the development of laparoscopic surgery. The first laparoscopic nephrectomy was performed by Clayman et al. in 1991. This milestone was gradually overtaken by a constant and very significant development, first of laparoscopic urological surgery and later of robotic-assisted urological laparoscopic surgery.

The natural evolution of this laparoscopic development has been the fact of making increasingly smaller incisions and also reducing the number of them, thus producing the development of laparoendoscopic single-site surgery or LESS. This new technique involves the coalescence of all access ports into a single one, through a skin incision that is often hidden in the navel.

Prior to its implementation in Urology, there have been reports of LESS surgery well before in other specialties like General Surgery and Gynecology. In fact, surgery through single umbilical port has been practiced for years by many surgical specialties. There have been many tubal ligations by a single access for years. More recently, general surgeons have performed peritoneal dialysis catheter placement using single umbilical port, retroperitoneoscopic adrenalectomies, and cholecystectomies.

In recent years, this type of surgery has evolved in a very striking way, there being multiple single-port devices and precurved instruments, with simple and double rotation systems. Thanks to this diversity, we managed to perform almost all the procedures that exist in Urology by means of this new approach. But different nomenclatures have been established to refer to the different procedures, at times somewhat confusing. The expression Natural orifice trans luminal endoscopic surgery (NOTES) refers to the use of natural orifices to perform the extraction of the surgical specimen. The natural orifices at our disposal are the mouth, vagina, and rectum. On the other hand, the surgery practiced through the natural orifice of the navel is called Embryonic-NOTES (E-NOTES). This approach matches the so-called umbilical LESS. Furthermore, due to the complexity of making pure NOTES, most studies were performed by means of the hybrid NOTES technique, which involves placing an additional 12-mm trocar at the navel.

The LESS technique can also be carried out in two ways. The first one is the pure single-access surgery; that is, all the ports that we are going to use will be inserted in a single incision, coinciding with the site of removal of the piece, and desirably, but not always, with the navel. The second one is through hybrid LESS, if required using one or more accessory trocars. This is done using fine trocars (needle-sopic), smaller than or equal to 3.5 mm in diameter, almost not leaving scars.

The most important advantages of all these techniques are that they have very good aesthetic results, with less postoperative pain and an early recovery from surgery, adding to these advantages the psychological aspect of having no visible stigmas of the disease, often tumor. However, in order to perform umbilical single-port surgery, we need to have the appropriate tools and be familiar with their use. For some, it is a restrictive and expensive surgery, particularly if disposable single-port elements are used. What is more, it takes a hard learning. There is no doubt that these limitations, not only economic, but also of experimentation and teaching, are a brake in the spread of this type of systems.

Materials and methods

The single port used is a reusable system produced by Richard Wolf called Keyport. This system requires no external fixation and it uses dual-rotation precurved instruments that allow for great versatility and precision of movement (Fig. 1).

Keyport comprises 3 parts of plastic material. The first one is a plug which is removed after entering the port. The second one is cylinder-shaped, which is inserted through
Figure 1 Necesssary reusable material for Keyport surgery. From bottom to top: 5-mm-wide and 45-mm-long lens, single port clamped system, and precurved dual rotation items, also clamped, that enable great versatility and precision of movements (Richard Wolf®).

The navel and is embossed on its wall by way of screw grooves, enabling its insertion turning in the opposite direction and preventing this piece from escaping. The diameter of this cylinder is 2.5 cm at the distal end, and 3.5 cm proximally. Therefore, the required incision is usually smaller than 3 cm, since the skin is elastic and it allows for its insertion without any problems. The third part, which is the external area, is formed by a blue lid that is attached to the internal one by small hooks. It has an access for the insertion of the pneumoperitoneum and three working channels of 5, 10, and 15 mm. The 15-mm port is located to the right, and it has different plugs to fit them to the size of the various working tools (5 and 10-mm Ligasure, different precurved work items, and 10 and 15-mm specimen extraction bags, mainly). The totally umbilical placement of the Keyport makes it possible to perform surgery without visible incision, since the incision is completely hidden in the natural scar of the navel.

Through the port that is situated in the middle area, the optic of 5 mm is introduced, but it also enables the passage of instruments of 10 mm if we want to work with the optic through another input. The remaining port, which is located in the left area of the Keyport, is 5 mm. It is very important to properly lubricate the various instruments and the optic for them to pass through the working channels. The optics that we use to work are two, one of 0° and another one of 30° depending on whether we work in the pelvis or in the retroperitoneum. Both have a length of 45 cm and a diameter of 5.3 mm. Being longer than normal helps avoid collision of the surgeons’ hands away from the patient and favors triangulation.

The working tools we use consist of double rotation precurved forceps (Duo-rotate). We have four different elements: grasper, fine-tipped forceps (Maryland), 5-mm dissector, and scissors. Each element consists of three components: (a) a handle with a trigger that changes the type of rotation, which may be only of the tip of the forceps or of the whole forceps; (b) an outer sheath; and (c) the mentioned working elements that avoid the outside crush, allowing for a correct triangulation (translational movement) and the mobility required by rotating the distal end thereof (rotation movement) (Figs. 1 and 2). Currently, there is no curved needle holder, so this function can be performed either with the distal end of the grasper (in a difficult way), or by inserting fine accessory ports from 2 to 3.5 mm in size, through which straight instruments can be inserted.

In the section ‘Results’, we describe the learning standards developed first in endotrainer and then in porcine model. We used 20 animals weighing between 25 and 40 kg for specific training with a single subxiphoid port, positioned at the navel, after notifying the Dirección General de Medio

Figure 2 Dry laboratory training with the suture exercise between probes. A. Pelvitrainer and tower arrangement. B. Detail of the suture with precurved items.
Ambiente de la Comunidad de Madrid, as established in the Royal Decree 1201/2005 of 10 October of the Ministry of the Presidency on protection of animals used for experimentation. Each animal underwent experiments in the following order: lymphadenectomy (pelvic, retroperitoneal, or both), nephrectomy (bilateral), bladder opening and cystorrhaphy (with continuous suture or stitches), and uterine-vesical anastomosis (unilateral).

**Results**

Initial training was developed by 2 surgeons experienced in laparoscopic surgery (PMC and FC), aided by 4 novice laparoscopists of the Urology Department of the University Hospital of Getafe (AGT, MS, FL, and GA), forming a double surgical team with rotary assistants. The first step consisted of two 2-h sessions to become familiar with the single-port system and the different instruments, learning to assemble and disassemble all the materials to avoid damage by misuse.

Having become familiar with the working of the material, 14 consecutive sessions were scheduled in dry lab with endotrainer exercises (mean session time of 7 h) for two consecutive weeks, each surgical pair (surgeon and assistant) performing a total of 49 h of controlled training. Triangulation was performed with the forceps to perform the various exercises correctly. The work items are crossed inside the endotrainer, in such a way that what we see on the monitor on the right is our left forceps and vice versa. This differs significantly from conventional laparoscopy, so an added skill is required.16,17

The specific exercises on which we worked were at first taking small rings, passing them from a forceps to the other, and leaving them in places that we had marked.18 Once the first step was mastered, we began working with the placement of the needle that we subsequently used for sutures. We did not move to the next step until we were able to place the needle without any problems, and with all possible orientations. The last exercise we did in the endotrainer was the continuous suture and with end-to-end interrupted sutures between two opposing pavilions of Foley catheter 20C.16 All these exercises were more difficult than expected, because we did not have precurved needle holder with which to work and it was necessary to use broad-tipped forceps or fine-tipped precurved forceps as needle holder. We also performed sutures with the help of a straight holder inserted through a 3.5-mm accessory trocar. Both experienced surgeons were able to perform all the exercises without any problems from the 40 h of controlled exercise.

Subsequently, the two main surgeons entered the experimental operating room (Figs. 3 and 4), performing together various techniques with the porcine model prior to scheduling the first human surgery. 20 sessions of experimental surgery were performed, with days of mean duration of 7 ± 1.38 h (median 7, range 5–9), to complete 140 h for each surgeon as assistant or primary surgeon, indistinctly (Fig. 5).

The median time for the different exercises performed is expressed in Table 1. The different procedures in decreasing order of time spent were: lymphadenectomy (100.5 ± 11.4 min), utero-vesical anastomosis (94.5 ± 28.6 min), unilateral nephrectomy (78.1 ± 22.1), and cystorrhaphy (69.2 ± 9.0 min). Table 2 examines the time spent comparatively between the first and the second ten animals. The surgical times were compared for

**Table 1  Descriptive analysis of surgical times for each surgery.**

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean ± SD</th>
<th>Range</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymphadenectomy</td>
<td>20</td>
<td>100.5 ± 11.4</td>
<td>90–120</td>
<td>100</td>
</tr>
<tr>
<td>Nephrectomy</td>
<td>40</td>
<td>78.1 ± 22.1</td>
<td>40–120</td>
<td>80</td>
</tr>
<tr>
<td>Cystorrhaphy</td>
<td>20</td>
<td>69.2 ± 9.0</td>
<td>55–90</td>
<td>70</td>
</tr>
<tr>
<td>Utero-vesical anastomosis</td>
<td>20</td>
<td>94.5 ± 28.6</td>
<td>50–130</td>
<td>95</td>
</tr>
</tbody>
</table>
the different exercises practiced. The timings of each surgeon were not compared because the different exercises in each animal were performed alternately. With the exception of lymphadenectomy, the other procedures are significantly longer in the first cases than in the latter ($p < 0.05$).

Lymphadenectomy in the early cases was only pelvic or retroperitoneal, and as experience increased, both procedures were performed without the surgical time increased. Similarly, cystorrhaphy in the early cases was practiced with continuous suture and in the following with interrupted sutures, without increasing the duration of the procedure either, but rather the contrary. The difference of times in the most complex procedures (uterovesical anastomosis, nephrectomy) was more marked. This fact implies that exercise improves learning.

The sutures were sometimes performed through the single port, with the added difficulty of not having a needle holder, and mainly using a 3.5-cm accessory trocar through which a straight holder was inserted. This KeyPort surgery with accessory fine item is the essential basis of some highly complex surgeries such as pyeloplasty, ureteral reimplantation, radical prostatectomy, cystoprostatectomy, or partial nephrectomy. They all share the need to conduct watertight and safe sutures, sometimes quickly.

Occasionally, the precurved instruments do not reach or exceed the required depth, which is corrected with more or less introduction of the single port system. Another problem encountered is that the alternating application of 5 and 10-mm Ligasure requires the additional coupling of a rubber stopper to prevent leakage of the pneumoperitoneum. We need to know and test all materials to be used for surgery in humans (bags of 10 and 15 mm, bulldog forceps of 15 mm, Hem-o-lok applicator), and it is very important to know that the possibility of maneuvering of the instruments is much lower. Therefore, we must be very careful not to have any type of injury, especially vascular, which is very difficult to solve. So, we will avoid turning Keyport surgery to laparoscopy or open surgery. It is always desirable before converting to use one or several fine accessory ports, without losing the concept of single port laparoscopic surgery.

### Discussion

Table 2  Comparison of surgical times between the first half of cases (group A) and the second half (group B).

<table>
<thead>
<tr>
<th>Variable</th>
<th>$N$ (total/A/B)</th>
<th>$Z$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lymphadenectomy</td>
<td>20/10/10</td>
<td>-1.40</td>
<td>0.161</td>
</tr>
<tr>
<td>Nephrectomy</td>
<td>40/20/20</td>
<td>-4.48</td>
<td>0.000</td>
</tr>
<tr>
<td>Cystorrhaphy</td>
<td>20/10/10</td>
<td>-2.79</td>
<td>0.005</td>
</tr>
<tr>
<td>Utero-vesical anastomosis</td>
<td>20/10/10</td>
<td>-3.80</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Figure 5  Laparoscopic images that show the major instruments. A. Fine-tipped forceps that is helping to place the needle on the left and the grasper on the right used as a carrier. B. Fine-tipped forceps and scissors. C. 5-mm dissector under the renal vein.

Apparently, the first laparoscopic procedure in Urology was conducted by Wickman in 1979 and it consisted of a laparoscopic ureterolithotomy. Anyway, until Clayman performed the first laparoscopic simple nephrectomy in 1991, this type of minimally invasive procedures did not gain importance. At first, the surgical time was very long, gradually being reduced to compete with open surgery.
Laparoscopic procedures have evolved, increasing the interest in esthetic results, which reduced the size of the trocars from 15 to 1.8 mm\(^{11}\) and defined the current LESS and NOTES techniques.

NOTES was introduced in Urology by Gettman et al., performing in 2002 the first transvaginal laparoscopic nephrectomy in the porcine model.\(^{21}\) In 2007, Raman et al. published the first LESS nephrectomy in human,\(^{23}\) and in 2009, Ribal et al. the first hybrid transvaginal nephrectomy for renal cancer.\(^{24}\) Since then, few centers have developed these techniques due to the difficulty of working in such small spaces that hinder triangulation and prolong the operating time.\(^{25}\) There are multiple studies published of NOTES surgery with experimental animals, especially with the porcine model, due to the complexity of such approaches.\(^{22,26}\) Also, the use of instruments with magnetic anchorage could facilitate the learning of porcine transumbilical nephrectomy.\(^{27}\)

Laparoscopy through umbilical Keyport in humans needs a solid learning in dry lab with the porcine model. This type of systems needs to know well the details and tricks of the curved equipment to acquire triangulation with small crush of the outer portion of the instruments, which needs to learn in an intuitive, but tested, way the movements of the surgeon’s cross instruments.\(^{17}\) We believe that it is very important to develop specific training programs that allow for urological procedures in humans with guarantees and within acceptable operating times.\(^{11,12,16,28,29}\)

Another aspect to consider is the high cost of disposable single-port accesses, so with this type of reusable system, it is notably reduced. All the exercises described were performed with a single set of instruments and lenses, replacing only two insertion elements due to the deterioration (scissors and grasper). We can say that the system exceeded the 400 h of useful life.

Work in the experimental operating room shows that Keyport laparoscopy is a more difficult technique than conventional laparoscopy due to the conflict of space that there exists. Furthermore, it should be noted that it is more difficult to solve any possible complications than with conventional laparoscopic surgery. Anyway, with good training, all problems can be minimized. Surgical times also shorten with increasing surgeon experience.

Conclusions

Training in single-port laparoscopic surgery, first in endotrainer and later with live swine in experimental operating room, is essential to become familiar with the Keyport material and to acquire ease with its use. Only a specific training program will allow procedures in humans to be performed in optimal surgical times and with safety guarantees for the patient. Furthermore, it should be noted that, being a more complicated surgical technique than the conventional laparoscopic one, the learning curve will probably vary depending on the experience and expertise of the surgeons.

Conflict of interest

The authors declare that they have no conflict of interest.

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