# History of Laparoscopy, Endoscopic Extraperitoneal Radical Prostatectomy and Robotic Surgery

## Contents

### 1.1 Historical Aspects of Laparoscopy and Endoscopic Extraperitoneal Radical Prostatectomy

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#### 1.1.1 History of Laparoscopy

3

#### 1.1.2 Laparoscopic Radical Prostatectomy

4

#### 1.1.3 Extraperitoneal Access – The Term “EERPE”

5

References

6

### 1.2 Historical Overview of Robotic Radical Prostatectomy

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References

8
1.1.1 History of Laparoscopy

“Laparoscopy“ is derived from two Greek words meaning “flank” and “insight.” Laparoscopy is the established term although „celioscopy“, meaning intraabdominal insight, would have been more accurate. Today “laparoscopy” describes a procedure during which contents of the intraperitoneal cavity or of the extraperitoneal space are examined and manipulated in a diagnostic or therapeutic intervention.

Although the term has been widely used in urology only in the past 15 years, the concept is actually more than 100 years old. It was at the beginning of the 20th century that Kelling experimentally insufflated the abdominal cavity of a dog and inserted a cystoscope to inspect the abdominal visceral organs [6] (Figs. 1.1.1, 1.1.2).

Urology began to embrace laparoscopy as an essential diagnostic procedure in the early 1970s. By that time urologists had started using laparoscopy to search for undescended cryptorchid testes that were entrapped in the abdominal cavity, anywhere along their route from the retroperitoneal space to the scrotum.

The status of laparoscopy in urology did not change dramatically in the following decade and it was always a diagnostic procedure only. It was not until the 1990s that two reports described another, more advanced use of laparoscopy in our specialty.

Clayman et al., in 1991, reported the first laparoscopically performed nephrectomy with simultaneous intracorporeal tissue morcellation and use of impermeable specimen sacs to permit organ removal through the endoscopic ports [2]. Some doubted whether morcellation of the kidney was an adequate method for organ removal in an oncologic setting. The first hand-assisted nephrectomy was described by Nakada and colleagues in 1997 and this has remained an alternative approach to radical nephrectomy [7]. Nowadays, radical nephrectomy has become the standard approach due to ongoing technical and technological refinements in laparoscopy.

Almost at the same time, Schuessler et al. reported the first laparoscopically performed lymphadenectomy for prostate cancer [10]. For many urologists, this procedure was the first and most intriguing insight into the world of laparoscopy.

Laparoscopic ligation of the spermatic veins for varicocele is a widely performed procedure and a good training opportunity to help urologists familiarize themselves with the laparoscopic instruments and the laparoscopic reality. The translation of the two-dimensional monitor picture into three-dimensional movement of the surgeon’s hands has a certain learning curve, and varicocele ligation is considered as an “entry” or training procedure for more complex operations.
The modern laparoscopic era has evolved dramatically over the course of the past decade. It is a worldwide reality that almost every single urologic operation, oncologic or otherwise, can be performed laparoscopically just as efficiently, and with fewer and less serious complications, as with conventional open surgery. UPJ reconstruction, retroperitoneal lymphadenectomy, radical nephrectomy with vena cava thrombus extraction, live donor nephrectomy during renal transplantation, radical prostatectomy, even radical cystectomy with continent diversion – from minor to major operations, urologists have managed to incorporate laparoscopy into everyday urologic practice.

The future is promising and exciting. The advent of robotic technologies and robot-assisted surgery, with and without tactile feedback, is already a reality in modern urological practice. Nevertheless, there is currently not enough evidence to show that these techniques indeed provide advantages over “conventional” laparoscopy, either in functional or in oncological outcomes. Furthermore, it has not yet been possible to demonstrate that robot-assisted surgery is cost effective.

1.1.2 Laparoscopic Radical Prostatectomy

As mentioned above, Schuessler and coworkers were the first to perform laparoscopic lymphadenectomy for prostate cancer prior to open radical prostatectomy [10]. The same group described removal of the seminal vesicles during laparoscopic lymphadenectomy [5]. In 1992 this group was the first to perform transperitoneal laparoscopic radical prostatectomies, and they published their initial series of 9 patients in 1997 [9]. They were not enthusiastic about the technique and concluded that “...laparoscopy is not an efficacious surgical alternative to open prostatectomy for malignancy....” This team was not able to define a clear advantage of laparoscopic surgery over the traditional open radical retropubic prostatectomy regarding hospital stay, continence and reconvalescence. It is noteworthy that these first operations lasted almost 9 h on average, which was considered a major drawback for the further development of the technique.

Raboy et al. described the first extraperitoneal radical prostatectomy and, in contrast to the Schuessler group, they were rather satisfied with the results of the new evolving technique [8].

In December 1997 Guilloneau and colleagues performed a transperitoneal laparoscopic radical prostatectomy in less than 6 h, and in January 1998 the same team started to perform their first series of laparoscopic radical prostatectomy [3, 4]. Laparoscopic radical prostatectomy soon became a widespread minimally invasive alternative to radical prostatectomy, so that by the year 2001 more than 1,200 radical prostatectomies had been performed, mainly in European centers. Ever since then a rapidly increasing number of urologic departments, both in Europe and the USA, have performed large series of this innovative minimally invasive technique. Many urologists have suggested various modifications of the original operation, including transperitoneal or extraperitoneal approach, antegrade or retrograde dissection and different neurovascular bundle-sparing techniques.

Over the past few years, laparoscopic radical prostatectomy has become the standard procedure for the treatment of localized prostate cancer in an increasing number of urologic centers in Europe and in the USA.

The well-known advantages of minimally invasive surgery over conventional open surgery have led to increasing interest worldwide in the further develop-
ment of laparoscopy in urology. These benefits include less postoperative pain, a shorter hospital stay, and faster resumption of normal activities along with a minimally invasive technique that provides better visualization of the operative field through the optic magnification, shorter catheterization time and minimal intraoperative blood loss. To the aforementioned advantages we have to add the fact that laparoscopic radical prostatectomy is oncologically just as efficient as the traditional open retropubic prostatectomy and has similar or better functional results in experienced hands.

In a recent survey in Germany, 35% of laparoscopically active departments already performed laparoscopic prostatectomy and almost all of the rest intended to introduce in the near future [19].

1.1.3 Extraperitoneal Access – The Term “EERPE”

The first laparoscopic prostatectomies described were performed using transperitoneal access. Despite the fact that the extraperitoneal route was almost simultaneously reported [8], the French team at the Montsouris center chose to develop the transperitoneal approach [4].

The groups in France refined and evolved the technique and reduced operation time to 3–4 h, not much more than a third of the time initially reported by Schuessler. Later on the French experience spread throughout Europe.

However, general skepticism persisted due to the fact that an extraperitoneal organ, the prostate, was being accessed by a transperitoneal route with possible intraperitoneal complications: bowel injuries, intraperitoneal bleeding, ileus, intraperitoneal leakage of urine, and acute infection of the peritoneal cavity are considered the main short-term or intraoperative complications, while intraperitoneal adhesion formation and subsequent chronic bowel obstruction with recurrent ileus are the principal long-term complications.

The perspective of an extraperitoneal approach to the prostate was developed after the initial report by Raboy and coworkers. The first series of 42 patients to undergo extraperitoneal radical prostatectomy was published by Bollens et al. in 2001 [1].

The extraperitoneal approach to radical prostatectomy bears the advantages of a minimally invasive technique for the removal of the prostate while overcoming the limitations of a transperitoneal approach (i.e., potential problems in visualization, and increased risk of intra- and postoperative intraperitoneal complications).

A further development of the technique was reported by Stolzenburg et al. as EERPE in 2002 [11]. The term endoscopic extraperitoneal radical prostatectomy (EERPE) was used to describe the totally extraperitoneal access to the prostate for radical prostatectomy. Based on the growing experience with this technique, the same group has proposed many modifications and improvements of this operation, including a standardized and reproducible nerve-sparing, potency-preserving approach [18]. Furthermore, preservation of the puboprostatic ligaments for better early postoperative continence rates, minimal blood loss, and the reliable oncologic results (regarding positive margins) have made this approach the standard and first option for the treatment of localized prostate cancer in many specialized centers [13, 14]. EERPE is an ever-evolving procedure. The latest technique involves intrafascial preparation of the prostate leaving the pelvic fascias intact [15]. This approach reflects the latest anatomical studies identifying neurovascular structures not only dorsolateral to the prostate but also within the prostatic fascia laterally and anterolaterally.

In contrast to “traditional” thinking, there are almost no limiting factors for minimally invasive radical prostatectomy and especially for EERPE. Previous abdominal or pelvic surgery, for example, is no barrier. Modifications of trocar placement and operative techniques have made EERPE possible even for patients considered unsuitable for minimally invasive surgery in the past [12, 16, 17].

It is of paramount importance to point out that the evolution of the technique has been assisted by advances in medical equipment and instruments. In the past few years the development of devices such as endoscopic clip applicators, harmonic scalpels and endoscopic multiple-use instruments, as well as two-component sealants, has promoted minimal invasive surgery in urology.

Today it is clear that EERPE has already reached (if not, indeed, surpassed) the standards of open radical prostatectomy. One of the major problems that many urologists face is the long and steep learning curve of laparoscopic procedures. Therefore, a new modular training concept has been developed for EERPE in or-
der to standardize the surgical training and shorten the learning curve of both laparoscopically experienced and laparoscopically naive surgeons [16].

In summary, today EERPE is a first-line option for patients with localized prostate cancer in a rapidly increasing number of urologic departments around the globe. Innovative developments such as EERPE, together with cutting-edge technological advances, enable urology to remain in the forefront of medical and technical development.

References

The development of minimally invasive laparoscopic techniques has had a profound impact on urology in the past decade. Despite the numerous patient-related advantages of many minimally invasive procedures, laparoscopic techniques are often more difficult to perform than corresponding tasks in open surgery. Indeed, the technical learning curve for minimally invasive laparoscopic techniques can be very steep. Laparoscopy can impose limitations on instrument manipulation (secondary to trocar positioning), dexterity (secondary to long non-articulated instruments), tissue palpation (lack of haptic interface), and vision (two-dimensional on flat screen). Robotic surgery has been developed to increase operative precision, decrease the learning curve, and thereby increase clinical applicability of minimally invasive laparoscopic techniques. Since the introduction of surgical robots, a rapid technologic evolution has been witnessed in urology [1, 2].

The first clinically available surgical robot in urology was purposely designed to hold a laparoscope [3]. This robot, called the Automated Endoscope System for Optimal Positioning (AESOP, Intuitive Surgical, Sunnyvale, CA), has one robotic arm with six degrees of freedom (DOF) that is directly mounted on the operating table [3, 4]. The robot is controlled using a foot pedal, joystick, or voice commands. Kavoussi et al. noted that AESOP improved image quality and eliminated the need for surgical assistants during a variety of laparoscopic procedures, including ureterolysis, pelvic lymphadenectomy, nephrectomy, and pyeloplasty [3]. Recently, Antiphon et al. demonstrated the feasibility of laparoscopic radical prostatectomy (RP) performed with the use of a single surgeon, self-retaining retractors, and AESOP [5]. The introduction of AESOP also facilitated the development of telementoring and teleproctoring, which have also made laparoscopic surgery more applicable [6].

Building on the foundations of the AESOP robot, more advanced robotics systems have been introduced clinically within the past 5 years. These robots were derived from experimental robotic systems developed in the early 1990s [7, 8]. More advanced robots, also known as master–slave robots, have a remote control unit that is used to control multiple robotic instruments and camera arms. Using master–slave robots, surgeons use hand controls to maneuver three or four mechanical arms placed inside the patient [1, 2]. All surgical movements are enhanced and replicated by the robot. For instance, the robot can potentially improve performance by filtering away physiologic tremors. One of the first systems was introduced by Bowesox and Cornum for open surgery [7]. The system used three-dimensional imaging and interchangeable surgical instruments positioned on two mechanical arms. Another innovative telerobot with tactile feedback (i.e. haptic interface) was similarly introduced by Schurr et al. with favorable experimental results [8].

From a historical standpoint, the Zeus robot (Intuitive Surgical, Sunnyvale, CA) was one of the first master–slave robots to be introduced clinically [1, 2]. When initially introduced, the robot lacked three-dimensional vision capability as well as articulated instrumentation. Given the design deficiencies, another robotics system called da Vinci has emerged as the leading telerobot to date in the operating room.

The da Vinci robotic system (Intuitive Surgical, Mountain View, CA) is also a master–slave robot that includes two or three robotic instrument arms, a camera arm, a standard three-dimensional imaging system, and a remote control unit [1, 2]. Since FDA approval of the initial da Vinci robot, more advanced versions of this system have been introduced [9]. For example, the so-called fourth-arm da Vinci robot reduces reliance on assistants when performing robotic surgery. The latest robot, called the da Vinci S, incor-
The technique of robotic prostatectomy is standardized for ureteropelvic junction obstruction [15]. In 2002, robotic pyeloplasty has been increasingly performed preferentially with visual cues and operating with high magnification, but da Vinci systems lack a force-feedback feature, require cumbersome robotic installation, can impair intraoperative communication, and are associated with high financial cost. In part, the additional costs of da Vinci are related to required use of interchangeable instruments with limited reusability [10]. Upon attaching the instrument to the robotic arm, the system automatically subtracts „life“ from the instrument.

Similar to conventional laparoscopy, a learning curve is also present with telerobotics. The robotic learning curve is thought, however, to be much less steep than that of conventional laparoscopy [1, 2]. Technical factors that must be overcome include operating preferentially with visual cues and operating with high magnification. The learning curve is also related to the teamwork between the remotely seated surgeon and the assistants steriley scrubbed at the operating table.

Robotic surgical techniques have been developed experimentally and clinically for a wide variety of applications in the upper and lower urinary tract [11–19]. Although telerobotic nephrectomies and adrenalectomies have been reported, robotic indications in the upper tract have favored reconstructive versus exirpative procedures. Since the clinical description in 2002, robotic pyeloplasty has been increasingly performed for ureteropelvic junction obstruction [15]. In the lower urinary tract, telerobots are most commonly utilized for RP, but other procedures such as radical cystectomy and urinary diversion are gaining momentum [16, 17].

Initial experience with da Vinci for laparoscopic RP was described predominantly at centers with significant experience in non-robotic laparoscopic RP or open RP [11, 18–20]. Since that time, interest in robotic prostatectomy has increased exponentially. The technique of robotic prostatectomy is standardized using either a transperitoneal or an extraperitoneal approach [11, 18–20]. Data comparing the results of da Vinci RP, open RP, and pure laparoscopic RP suggest that the robotic technique is at the very least equivalent to the other techniques at short-term follow-up [19]. Ongoing evaluation of outcomes data is required to further understand the clinical advantages of robotic prostatectomy in comparison to other prostatectomy techniques.

In summary, robotic surgery has rapidly developed in urology. For many urologic problems in the upper and lower urinary tract, a standardized approach with a surgical robot is considered a bona fide treatment option. At the present time, robotic surgery in urology is most commonly used for RP. The technique is increasingly being successfully embraced by surgeons with or without prior experience in laparoscopy using either a transperitoneal or an extraperitoneal approach. Longer follow-up and analysis of outcomes data is needed to confidently determine safety of all robotic procedures. Nonetheless, robotics does appear established in urology and is expected to continue to have a favorable evolution and impact on future generations of surgeons with improved telecommunications, imaging, computer technologies, miniaturization, and the advent of virtual reality.

References

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