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Robot-assisted surgery *vs.* laparoscopy surgery: which is better?

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This article belongs to the Special Issue: Robot-assisted surgery vs. laparoscopy surgery; which is better?

Abstract

Minimally invasive surgery is a rapidly evolving field, and over time, robot-assisted surgery is being used in more and more centers around the world. This evolution is boosted by the recent introduction of multiple different robotic platforms. Robot-assisted surgery is an evolution of a laparoscopic one, therefore there are multiple points that we can compare in order to be able to overcome a simple passion for technology and modern. Despite the long-standing presence of laparoscopic surgery, we cannot overlook the dexterity shift, easier training of novice surgeons (various digital training platforms and dual-console availability), shorter learning curve even for complex procedures, faster transition from open procedures to their robot-assisted counterparts, lower physical load and mental stress, and hospital benefits (especially in high-volume centers) that arrive with the adoption of robotic system.

Keywords: Laparoscopic, robot-assisted, comparison, benefits, difference

Introduction

Medicine is technologically very rich. And over time, it gets even richer as new discoveries and new devices started to be used in daily practice. As urologists, we are no different, and over time, many pathologies have been treated in a minimally invasive way, instead of the open approach. The minimally invasive (MI) approach started with urinary tract endoscopy (diagnostics, resections, *etc*.), continued with laparoscopy (LAP), and now we witness the boom of different robot-assisted surgical platforms. The history of human laparoscopy began in 1901 when G. Kelling performed a diagnostic abdominal examination on a dog using a Nitze cystoscope [1]. Then, in 1910, Jacobeaus performed a diagnostic laparoscopy for functional abdominal complaint [2]. Other steps (cold light, CO_2 insufflation, cautery, cameras, hemostasis, *etc*.) followed over the next decades. The evolution went from diagnostic procedures to ablative and later reconstructive ones.

For example, the Swiss gynecologist Zollikopfer began using CO_2 instead of air for abdominal insufflation in 1924 [2]. The German gastroenterologist Kalk (also a founder of the German school of laparoscopy) developed a 135-degree lens system and a double trocar [3]. The first "operative" laparoscopic surgery can be traced back to 1933 (or rather its publication), when a laparoscopic adhesiolysis was performed [4]. A further step towards safe laparoscopy was the introduction of the insufflation needle with safety spring mechanism by the pneumologist Veress [5]. Regarding the initial difficulties in accessing the abdominal cavity, early experience with the natural orifice approach was made by the American Albert Decker, who created the transvaginal approach as early as 1946 [6].

The German gynecologist Kurt Semm devoted much of his career to endoscopy, and later to laparoscopy, beginning in 1955. He also developed some devices and instruments himself, such as his version of an automatic CO_2 insufflator in 1963 [7]. Later, he also developed a suction irrigation device, an electronic insufflator, and the first morcellator in 1977 [7]. Other technical advances that

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made laparoscopy safer were thermocoagulation in 1973 and later the Roeder loop for hemostasis [7].
It was also Semm who performed the first laparoscopic appendectomy in 1980, but his publication was not accepted until 1983 due to fierce resistance from publishers who did not believe in the future of this technique [8]. Then in 1985, the German surgeon Erich Mühe performed the first laparoscopic cholecystectomy [9].
In 1987, urologist John Wickham published his vision of endoscopic procedures and first used the term "minimally invasive surgery" when he reported on the first in Britain's department of such kind [10].
The history of laparoscopic urologic procedures begins with a diagnostic laparoscopy for cryptorchidism performed by Cortesi in 1976 [11], but LAP orchiopexy (only the first step of the Fowler-Stephen technique) was performed by Bloom in 1991 [12]. After that, there were many interesting achievements with operations performed laparoscopically, and we will mention some of them. In the same year as Bloom, Ralph Clayman performed the first transperitoneal nephrectomy and later a nephroureterectomy [13, 14]. The report of retroperitoneal radical nephrectomy was also published in 1991 by Gaur with mention of ballon space dilatation and the first LAP radical prostatectomy was reported by Schuessler [15, 16]. One year later, in 1992, Winnfield reported LAP transperitoneal partial nephrectomy (for benign disease) [17]. Then in 1993, Kavoussi with Peters published the first case of complete LAP dismembered pyeloplasty [18]. In 1995, Ratner published a successful LAP donor nephrectomy with only 5 minutes of warm ischemia time and immediate graft function [19]. The wider use of LAP radical prostatectomy came after the presentation of the Montsouris technique by Guillonneau and Vallancien in 1999, which made individual steps easier to reproduce [20].
Robotic assistance as we know it today with manipulation inside the body from a bedside console started in 1997 when Himpens and Cadière performed a robot-assisted (RA) cholecystectomy in a morbidly obese patient using the MONA system, later the ZEUS system was used for the two aortocoronary bypasses by Reichenspurnen in 1999 [21]. The first generation da Vinci system was introduced in Europe in 1999 and received FDA approval in 2000 [22]. The first RA radical prostatectomy was performed by the German team in Frankfurt by Binder and Kramer in May 2000 [23]. This was followed by a progressive uptake of RA surgery, especially in the United States, and in 2004, Menon *et al*. published their standardized Vattikuti technique with excellent functional and oncological results [24]. Other important achievements include the publication of RA radical cystectomy by Menon in 2003 [25], RA partial nephrectomy by Gettman in 2004, and RA radical nephrectomy by Klinger in 2005 [26, 27].
The beginning of single port access in urology dates back to 2007 and the publication of single port (SP) laparoscopic nephrectomy (plus orchidopexy, orchidectomy and ureterolithotomy) by Rane *et al* [28]. The first single-site robotic interventions (radical prostatectomy, pyeloplasty and radical nephrectomy) were performed in 2008 by Kaouk *et al*. using the da Vinci S robot through a 2 cm transumbilical incision [29]. The dedicated single-port da Vinci SP system was introduced in 2018, and soon after, Kaouk published the first experience with the SP system in nine patients [30, 31]. Currently, several robotic platforms are available worldwide, although not all are approved in all markets. As a further evolution, some SP systems have become available.
The history of MI surgery has been littered with debates about its usefulness, costs, training, benefits, *etc*., since its inception. These debates have sometimes been very heated. As a historical example, one of the pioneers of laparoscopy, Kurt Semm, had to undergo a head CT after returning from the operating room in the early 1980s after performing a laparoscopic appendectomy to rule out brain disease [32]. Even now, after many years, the discussions continue, but on other topics such as the differences, benefits, and equivalence or superiority/inferiority between the LAP and RA approaches.
The comparison between LAP and RA platforms is complex. There are many possible aspects to consider, such as perioperative clinical parameters (length of surgery (LOS), blood loss (BL), complications, length of stay (LS)), patient access to surgery in the public or private sector, hospital costs or patient out-of-pocket costs or overall financial impact on the patient due to length of recovery, long-term clinical impact such as the likelihood of cancer recurrence. Another important issue is the feasibility of challenging cases through MI surgery. We can continue to the comfort of the surgeon (ergonomics during surgery or his/her physical well-being such as short- and long-term body pain, cramps, *etc*.). Finally, we should not forget the training of young surgeons—its complexity, duration and possibility to reach the expert level, surgeon's autonomy and reproducibility.
In addition, debates about differences may be specific to the type of surgical procedure (radical prostatectomy, partial nephrectomy, cystectomy, *etc*.) and to differences in health care systems between countries. Although this topic is too large for a single article, we will try to cover points of interest from a current perspective.

Basic technical points

The main differences between LAP and RA procedures are the instruments and their degrees of motion. RA platforms are equipped with articulating instruments that typically offer 7 degrees of motion [33] (insertion and withdrawal; rotation; up/down movement; lateral movement; grip; wrist extension and flexion, which can be up to 90° depending on the type of instrument) [34]. This is superior to a straight laparoscopic instrument with only 5 degrees of freedom [35], even in an experienced hand. Robotic instrument maneuverability is close to that of the human hand. Therefore, the transition to RA surgery is usually easier for open surgeons compared to LAP surgery because hand movements are easily replicable compared to manipulation with a straight instrument and due to the fulcrum effect in laparoscopy (which is absent in RA intervention). Visual quality is certainly part of surgical learning. Typical RA system is equipped with three-dimensional (3D) vision based on the two optics on one camera piece (either with a head in the console or 3D glasses for new open consoles) [33]. A typical LAP system is equipped with one lens in one camera: Although there are LAP systems with 3D videoscopes too, but the majority are usually equipped with high-resolution 2D screens [36, 37]. Performing surgery under 2D *vs*. 3D visualization is less intuitive and takes more time to master. Therefore, for complex tasks and especially for novice surgeons, 3D visualization offers better comfort and results, such as less blood loss and shorter operative time in radical prostatectomy (RP) [38-40]. Ultra-high resolution (4K) laparoscopic systems are also available and seem to be at least as good as 3D laparoscopy for more complex tasks such as suturing [41].

Regarding the vision quality improvement, the simple transition from 2D to 3D in manually demanding scenarios such as MI partial nephrectomy improves perioperative clinical outcomes such as shorter total surgery time, shorter warm ischemia, and lower hemoglobin decrease [36]. The actual combination of improved dexterity and enhanced vision are some of the factors that contribute to the preference of the RA approach over LAP among those who have experience with both.

The downside of RA platforms is undoubtedly their technical complexity and bulky size (compared to a typical LAP). With this comes the increased cost of annual technical maintenance. Both LAP and RA training platforms exist and will be discussed further.

Major differences in favor of robotic procedures exist in single port (SP) systems. SP surgery is certainly possible with a pure LAP approach, but its complexity limits its use to extremely experienced LAP surgeons or specific scenarios. The robotic SP platform offers the benefit of ease of manipulation (compared to LAP) while maintaining the safety of multi-port procedures [42, 43]. The details of SP and RA surgeries are beyond the scope of this article and will not be discussed further.

Surgical training and simulation

Surgeon training is a continuous process that begins with basic anatomical landmark recognition, progresses through technical skill acquisition, and continues with improvement in various aspects of the procedure and clinical outcomes. For both LAP and RA training, initial observation is facilitated by the presence of one or more monitors during the procedure (anatomical orientation). Acquisition of technical competence is achieved through manual training. However, the number of repetitions required is different for each trainee. Dry and wet models are available for LAP and RA procedures [44]. LAP simulators are either homemade basic ones (especially in the past) or can be used as stand-alone or computer-based virtual platforms [45]. RA training platforms are uniformly computer-based; they are more complex and expensive. A clear advantage of virtual simulators is an absence of any single use or reusable material need. Manufacturers of RA platforms often offer a virtual simulator for on-site training, and there are multiple companies who provide their systems [44]. Examples include the da Vinci™ Skills Simulator (Intuitive Surgical), the Mimic dV-Trainer (Mimic), the RobotiX Mentor (CD Systems, Simbionix Products), the ProMIS Simulator (Haptica, Ireland), the Surgical Education Platform (SimSurgery), the Robotic Surgical Simulator (Simulated Surgical Systems), and the Hugo Robotic-Assisted Surgery (Hugo RAS) Simulator [44]. These contain individual steps or tasks, and some include virtual interventions [46]. Despite higher initial costs, they have long sustainability. The use of surgical simulators resulted in shorter surgery durations, decreased occurrence of complications, and better overall outcomes [47].

The added benefit of RA training is the existence of a dual console option, which is impossible in LAP surgery. In LAP there is only one surgeon with a dedicated position, role changing needs swapping places. Such need is absent in dual console surgery. In this case, the trainee or fellow may safely carry out the surgery under the continuous proctor control and it has been shown that dual-console *vs*. single console training reduces the OR time and risk of complications [48, 49].

The adoption of LAP or RA steps/procedures is certainly different based on individual innate skills. However, repetition and reproducibility play a major role [50]. In this regard, robotic training is easier to reproduce because of virtual simulators and dual-console [45, 51]. For those without MI surgery experience, adoption of RA skills is faster than learning the skills laparoscopically, for example with more sutures performed with fewer errors within a time limit [52, 53]. Those who have previous laparoscopic experience adopt robotic skills faster and the difference is greater for complex tasks [54, 55].

However, in systematic evaluation, the results are less clear, as some studies have shown a benefit of prior laparoscopic training [54], but there are other reviews that do not show such a benefit [56]. Also, parameters other than time, error, and quality are measurable in training. We can use specialized tools to measure skills such as OSATS (Objective Structured Assessment of Technical Skills) and M-GEARS (Global Evaluative Assessment of Robotic Skills) [57]. The use of robotic learning was shown to reduce frustration scores and improve good mood scores during and after training [52]. The differences were also less pronounced for surgeons with previous LAP experience [52].

Technical challenges (or their absence) contribute (among others) to the learning curve of the procedure. There are multiple reports of learning curves of certain procedures (although definitions of learning curve may vary). Using radical prostatectomy as an example, Abboudi *et al*. state that for open radical prostatectomy it ranges from 250 to 1000 cases, for laparoscopic radical prostatectomy (LRP) between 200 to 750 cases, and for robot-assisted radical prostatectomy (RARP) to be from 40 cases [58]. And in a large Australian analysis, the average learning curve for RARP was about 65 cases for those with no previous robotic experience [59]. Similar results favoring a faster learning curve for the RA intervention over a LAP procedure were published by Hanzly *et al*. with better outcomes in operating room time (161 *vs*. 203 minutes, $P < 0.001$), warm ischemia time (17.7 *vs*. 21.8 minutes, $P < 0.001$) [60]. Minimally invasive adrenalectomy is another possible example. The systematic review by Tarallo *et al*. shows that in most cases the duration of surgery stabilizes and the rate of conversion to open surgery decreases after 30-40 procedures [61], whereas in RA adrenalectomy proficiency was considered after 8-29 cases and a significant reduction in operative time already after 20-30 cases [62].

Transition between laparoscopy and robot-assisted surgery

There are many experts who can perform both LAP and RA surgery, as is in "natural evolution" of the previous generation of surgeons. The shift is typically from LAP to RA (open LAP RA or directly from open RA), or currently switching among different RA systems, but there are no reports of transition from RA to pure LAP intervention only [56, 63].

Just as it was easy for an experienced LAP surgeon to switch from one manufacturer to another in the past, it is now easy to switch from one robotic platform to another as the fundamentals are similar. However, switching to/from another robotic platform does require training to become familiar with the technical differences [64-66].

A few years ago, the RA surgery was reserved for the most complex cases and the easier ones were often performed laparoscopically. This principle is clearly outdated, as less complex procedures performed robotically serve as training to increase the autonomy of junior surgeons and fellows, who become familiar with the RA platform much faster and become independent sooner. For example, radical nephrectomy acts as "training" for partial nephrectomy or robotic nephrectomy with thrombectomy or with extensive retroperitoneal lymphadenectomy (kidney exposure, hilar dissection, hemostasis, *etc*.) or robotic sacrocolpopexy as preparation for female pelvic surgery or even cystectomy (personal opinion) [67-69]. Such "less complex" (not necessarily "easy") procedures also enhance the surgeon's perception of correct anatomy and tissue handling, typically based on visual control of tissue deformation, as haptic feedback is lacking in LAP and RA surgery.

Ergonomics

The surgeon's comfort during intervention is very important, as intervention may sometimes be complex or multiple simple ones may follow during one surgical session. Laparoscopy requires the surgeon to be positioned at the operating table, typically standing with a hand position adapted to the target operated organ or area (pelvic or abdominal). Pelvic surgery in particular, which is typical for urologists, is physically demanding. That may transform to peri- or post-procedural pain in the head, neck, shoulders, back, and sometimes legs [39]. Such physical effects of laparoscopy are more prominent in higher volume surgeons and more often affect the dominant hand or side [70, 71]. Therefore, robot-assisted procedures greatly changed the lives of minimally invasive surgeons. In a physician perspective survey of 106 surgeons comparing open-LAP-RA intervention, neck and/or back pain was reported in 50%, 56%, and 23% of participants after open, LAP, and RARP, respectively. And 32% reported that RA surgery caused the least pain of the three, 28% reported no pain, and only 3% reported that the robot caused more pain [72]. Overall fatigue perception was also measured after LAP and RA surgery, with no difference in dexterity and muscle fatigue measured by dynamometer after robotic procedure, while there were significant differences in hand grip strength of both hands after LAP intervention [73]. In a survey of seventy-nine surgeons, the authors found the highest physical demands for open and lower for robotic surgery, with only 7% of surgeons reporting neuromuscular skeletal disorders compared to 60-67% for endoscopic, open or laparoscopic cases [74]. Robot-assisted surgery also resulted in reduced cognitive load compared to LAP [75, 76].

In a systematic review comparing RA, LAP, and open surgery, the authors concluded that robotic surgery is ergonomically superior to the other two approaches, with ergonomic benefits, reduced workload, and less self-reported discomfort for surgeons and trainees [77].

Ergonomics is also important from the point of the increasing percentage of women in surgical disciplines. Based on the systematic review, female surgeons reported twice as much pain after laparoscopic tasks with compared to male colleagues, and also female surgeons and surgeons in general with small glove size reported more likely difficulties and need modified grip with standard LAP instruments [78]. Therefore, any robotic platform has a clear advantage over LAP systems with its ability to fine-tune the position (especially the working height) to each surgeon's (he/she) anthropometry.

Ergonomics of movement is also related to the degrees of freedom (DOF) that instruments can perform. A typical laparoscopic instrument is capable of up to 5 DOF [35, 79], while comparable robotic instruments have 7 DOF [35]. Manipulation with a LAP instrument is via the fulcrum (mirror-like), as opposed to the natural movements of the robotic arms that follow hand movements. Especially for a novice LAP or robotic surgeon, this is a clear advantage. Although motorized laparoscopic instruments exist for specific tasks that can mimic the 7 DOF of the robotic system [80], their use is currently rather limited. Easier manipulation with such instruments is still linked to the surgeon's position next to the patient.

Part of the ergonomic difference between RA and LAP systems is 3D *vs*. 2D vision. Visual symptoms are present after working in both 2D and 3D. Eye strain is greater after 2D procedures, but on the other hand there is greater difficulty in refocusing after working in 3D vision [81]. The ophthalmological examination of surgeons 30 minutes after surgery did not show any difference for those working robotically, but found significant discomfort for those working laparoscopically [82].

Advanced instruments and surgeon autonomy

Advanced instruments for hemostasis and tissue cutting/sealing or stapling are available for both LAP and RA systems. Tissue sealing and cutting for LAP is only available with the same degree of freedom as other LAP instruments (*e.g.*, ultrasonic vessel sealing); however, robotic platforms have a similar mode of action with an articulated tip and therefore may offer certain manipulation advantages and improved surgeon autonomy that is less dependent on assistants. The same applies to clip applicators. Surgical stapling is available for both laparoscopic and robotic use. However, when a stapler is used during a laparoscopic procedure, the surgeon must use his or her dominant hand or both hands to perform the task (depending on the type of device, whether it is motorized or not), and in a complex situation, this can be a complex task that is highly dependent on the assistance of an assistant. Stapling in RA surgery is available as an articulated instrument that can be used in one arm or position with the help of two other arms to work, plus the advantage of an assistant for complementary action. Increased surgeon autonomy allows for improved performance and precision. A randomized study of stapling (LAP *vs*. RA) in novice RA surgeons showed that LAP novices (but not LAP experienced) performed RA stapling with better performance (measured by the validated Anastomosis Objective Structured Assessment of Skills score). Mental and physical workload was higher for LAP stapling [83]. Complex procedures or those in less accessible compartments (*e.g*. radical cystectomy, partial nephrectomy, nephroureterectomy, radical prostatectomy) performed laparoscopically require a skilled and ideally experienced assistant to be carried out with best efficacy. This level of skill is difficult to obtain in junior surgeons or in places with high personnel fluctuation. Robotic surgical systems offer a high degree of autonomy with much less impact on previous surgical skills. Also, the use of intraoperative ultrasound in partial nephrectomy is easier with the robotic system compared to a laparoscopic system. The current state of the art is the use of a drop-in ultrasound probe that can be freely manipulated in any direction by the console surgeon, compared to certain difficulties associated with conventional laparoscopic ultrasound probes that are manipulated with greater difficulties [84]. Another example of a possible increase in robotic surgeon autonomy is the of ROSI (remotely operated suction irrigation), which may result in reduced blood loss and operative time [85].

Surgical outcomes of laparoscopic and robotic procedures

This is a hot topic, but it depends on several factors. These factors include the complexity of the case, the experience of the surgeon, his previous case load, but also the skills of the assistants, the operating room staff, the volume of the hospital and finally the technical equipment used. Data in the literature are often equivocal due to high bias and depending on the parameters reported. Finally, the results are variable for different procedures.

Partial nephrectomy is an intervention with ablative and reconstructive part with a time factor of warm ischemia (if vascular clamping is used). Results vary depending on the tumor complexity. However, a recent systematic review by Ruis Guerrero *et al*. found that robotic-assisted partial nephrectomy (RAPN) has a slightly shorter warm ischemia time compared to LAP and PN [86]. Changes in estimated glomerular filtration rate (GFR) are mostly dependent on the preoperative quality of renal function. Similar findings have been observed by others [86]. Differences in PN occur in complex cases with high nephrometric score, large or central tumors [63, 87]. A meta-analysis of nearly 5000 cases by Leow *et al*. also found that RAPN, compared to LAP and PN, was performed in larger tumors with higher nephrometric score and had a lower likelihood of conversion to LAP/open surgery, and both types had similar operative time, blood loss, and change in GFR [88].

Radical nephrectomy in experienced hands is performed laparoscopically as well as robotically, but differences in favor of the RA approach come in very complex cases with local involvement (liver, pancreas, *etc*.), tumor thrombectomy required or voluminous tumors [89].

Radical prostatectomy (RP) is the most common minimally invasive urological intervention. A multicenter European study comparing functional results or RA and LRP found that function results as 3-month continence were improved in the RA arm [90]. Interestingly, a meta-analysis of randomized trials showed no difference in 12-month continence, but improved potency (OR = 4.05) in previously potent men after RARP [91]. The comparison is naturally difficult, because of the multiple existent techniques (transperitoneal, extraperitoneal, Retzius sparing, *etc*.) and further nuances during the case (such as bladder, neck sparing, ligation *vs*. cutting the complex first, lateral approach, *etc*.). Therefore, other factors also decide, but mainly the more natural manipulation with the RA system and its shorter learning curve. A systematic review of open, laparoscopic and robotic RP found a learning curve of RARP about ten times faster than that of LRP [58].

Randomized trials exist for comparison of open and RA radical cystectomy, but not for LAP *vs*. RA [92]. In an observational study (comparing open, LAP and RA surgery) of patients with neurogenic bladder who underwent cystectomy with ileal conduit, the authors found that the RA approach was linked with the lowest likelihood of major complications (10% for RA, 23% for open and LAP), while the overall complication rate was similar [93].

Cost comparison

There is no doubt that the cost of purchasing and maintaining a system is higher for robotic platforms compared to a laparoscopic tower and equipment, regardless of the country potentially analyzed. However, the cost-effectiveness comparison would be highly dependent on the country, the healthcare system, the length of hospital stays, the materials/instruments used and, of course, the differences in surgical techniques. Costs have also evolved over time, and such a comparison from many years ago is certainly no longer valid. We can find some recent examples.

A cost-utility analysis from the Netherlands based on long-term outcomes showed that RARP was cost-effective compared with LRP over time, but mainly in high-volume hospitals (> 150) [94]. Similarly, an analysis from the United Kingdom noted that RARP cost £1785 ($2350) less and had 0.24 more quality-adjusted life-years gained compared to LRP, and the authors concluded that RARP has incremental cost-effectiveness ratios lower then willingness to pay threshold and is therefore a cost-effective option compared to open or LRP [95]. From a hospital's point of view, robotic adoption resulted in a 50% reduction in length of stay, 49% decrease in postoperative length of stay, and 44% and 46% decrease in postoperative visits at 1 and 2 years, respectively. Total hospital production increases between 21% and 26% and was linked with a 29% improvement in labor productivity [96].

The French study by Ploussard *et al*. compared the costs of RA, LAP and open RP on the data from 2020. RARP was associated with reduced direct stay costs (€2286) compared with open RP (€4298) and LRP (€3101). The costs were mainly dependent on the length of stay and although there were higher direct costs for the robotic system, these were balanced by improvements in patient care and reduced costs due to a shorter stay [97].

An American study of 1-year costs for RA and LAP partial and radical nephrectomy found that for an index surgery, the RA approach was associated with shorter hospital stay for both partial and radical nephrectomy, and lower open conversion and expenditures for PN. RA and LAP had comparable total 1-year expenditures, despite fewer healthcare visits for RA surgery in radical nephrectomy. The mean difference between RA and LAP was $475 for partial nephrectomy and $4,204 for radical nephrectomy (*P* = NS in both) [98]. In a French study reporting the cost of surgery carried out in 2019, the total cost per patient was €6857 for RA RP and €6034 for RA partial nephrectomy. The costs of surgery, hospital stay, and complications were 76.2%, 21.5%, and 2.3% for RA partial nephrectomy and 74.1%, 25.9%, and 0% for RARP. Standard laparoscopic procedures were less expensive. The authors conclude that direct surgical costs were higher, but with reduced hospital costs and morbidity [99].

Conclusions

When two technologies are compared, multiple factors play a role. Nevertheless, one cannot ignore technological advances, mechanical dexterity, standard 3D vision, and possible magnification and number of arms in robotic systems. All of these factors favor robot-assisted surgery over laparoscopic surgery. The highest benefit of robotic surgery is in complex, reconstructive of multi-quadrant procedures (radical cystectomy, prostatectomy, nephroureterectomy or partial nephrectomy, or other complex reconstructions). Robotic platforms make it easier and faster to train young surgeons, allowing them to become independent more rapidly. The availability of sophisticated and highly realistic surgical simulators with virtual procedures. The literature is also rather clear reporting on lower physical and mental impact of robotic surgery, as compared to conventional laparoscopic procedure. This is especially true for high-volume surgeons or in long and complex cases (such as radical nephrectomy with caval thrombectomy or radical cystectomy with intracorporeal diversion). With the arrival of multiple new robotic platforms, their adoption will become faster. And in recent years, the cost difference between robotic and laparoscopic procedures has been shown to be quickly surpassed by lower hospital, healthcare system and patient costs.

Laparoscopy is not over yet, as there are many countries or healthcare systems that are still struggling with the initial cost of robotic systems. But robotic surgery has several objective advantages that make it the preferred choice for patients, surgeons and hospitals. However, we should not be overconfident that the technology itself will make anyone a proficient surgeon, and it is only proper training, supervision, experience and continuous evaluation of one's results that will define the outcomes for our patients.

Declarations

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