Clinical and Experimental Obstetrics & Gynecology

Clin. Exp. Obstet. Gynecol. **2023**; 50(1): 13
https://doi.org/10.31083/j.ceog5001013

Review

Robotic Surgery and Deep Infiltrating Endometriosis Treatment: The State of Art

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Academic Editor: Christos Iavazzo
Submitted: 22 July 2022 Revised: 19 September 2022 Accepted: 22 September 2022 Published: 12 January 2023

Abstract

Objective: Surgical treatment of endometriosis, when indicated, has demonstrated to be effective in reducing painful symptoms and improve quality of life of patients affected with endometriosis. The minimally invasive approach via laparoscopy is the preferred method when compared with laparotomy but in the last two decades another minimally invasive approach has become available, the robotically assisted laparoscopic surgery. Robotic technology is widely used in different surgical branches, such as general surgery and urology. Moreover, the use of robotic surgery is already accepted for different gynecological procedures either for benign and for oncological diseases. The advantages of robotic surgery such as improve dexterity of movements, avoided tremor, increased magnification of 3-dimensional vision seem strategic in the context of a complex surgery as is deep endometriosis eradication. However, to date there is no unanimous consensus on whether robotically assisted procedures are a valid and safe alternative to laparoscopy in the treatment of endometriosis. **Mechanism**: In this narrative review we analyze the available literature assessesing the robotic treatment of all types of endometriosis and specifically deep infiltrating endometriosis, compared to the outcomes of conventional laparoscopy. **Findings in Brief**: Indeed, the evidence of safety and effectiveness of robotically assisted laparoscopy in endometriosis treatment is strong and almost unanimous. There is no clear superiority of one approach to the other but robotic-related advantages and future prospective are promising to be able to improve operative outcomes, reduce surgeon's fatigue and provide a technology easy to implement with a fast learning curve. **Conclusions**: Robotic technology applied to laparoscopy in the treatment of endometriosis could be seen as an effective and safe alternative to the conventional laparoscopic treatment.

Keywords: robotic surgery; deep endometriosis; laparoscopy

1. Introduction

Endometriosis is a very common gynecological disease, which affects nearly 10% of the female population in reproductive age [1–3], accounting for 38% of women with infertility and 71–87% of women with chronic pelvic pain [4]. Moreover, it is estimated that about 20% of patients with endometriosis are affected by deep infiltrating endometriosis (DIE), which is correlated with worse symptoms and quality of life [5].

Treatment options are multiple and different but even more variable is the response of the patients to each treatment, being it dependent to age, body characteristics, fertility status, patient compliance and patient's desires. Two main approaches have been described for endometriosis treatment, not excluding one another: medical hormonal therapy and surgery. It is widely accepted that endometriosis should be considered as a chronic disease that requires a life-long management plan with the goal of maximizing the use of medical treatment and avoiding repeated surgical procedures [6]. Nevertheless, surgical excision of the endometriotic lesions can significantly reduce painful symptoms and improve the quality of life of patients [7–10].

Moreover, some clinical conditions represent a mandatory indication for surgery. These comprehend those conditions in which an organ's function is at risk, such as the presence of bowel occlusion or subocclusion due to a deep nodule, a reduced kidney function or hydronephrosis caused by ureteral stenosis. In addition, surgery should be proposed to all symptomatic patients who do not respond or have contraindication to the use of medical therapy.

Since the first reports of application of laparoscopy in the diagnosis and treatment of endometriosis, the minimally invasive approach has demonstrated to be the preferred method when compared with laparotomy [10,11]. In the last two decades, the robotically assisted laparoscopic

surgery (RALS), has become available in different specialties. This approach has gradually become a frequent choice, even in gynecology, demonstrating good results in terms of reducing trauma and shortening the length of hospital stay [12]. Specific advantages of RALS try to overcome specific limits of conventional laparoscopy, such as the improved dexterity and coordination RALS provides thanks to the seven degrees of freedom of the instruments, the filtering of physiologic tremor, the increased magnification with its 10X view/three-dimensional vision and, not least, the decrease of surgeon's fatigue [13–16]. In the context of DIE surgery, these advantages may facilitate the correct dissection of planes and complete eradication of endometriosis, thus improving the success of the procedures [17,18].

On the other hand, to date there is no large consensus on the feasibility, safety and effectiveness of robotic surgery for endometriosis although many experiences have been published.

This is a narrative review of the available literature on the implementation of robotic technology in the surgical treatment of deep infiltrating endometriosis, summarizing the evidence and shedding light on the "blind spots", on the aspects that are still unclear or not fully investigated.

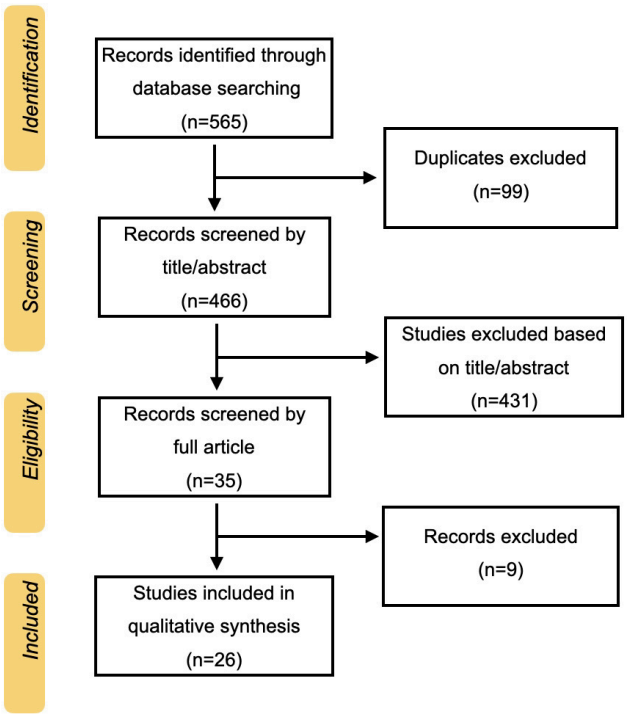

Fig. 1. PRISMA flow chart for studies selection.

2. Materials and Methods

A comprehensive literature review was performed using electronic databases (PubMed, Cochrane, Embase). All languages studies regarding robotically-assisted laparoscopy and endometriosis have been evaluated along with their references from April 2005, when the Food and Drug Administration (FDA) has granted the use of robotic technology to perform laparoscopic gynecological procedures, to March 2022. The following key words were used in the search: "robotic surgery", "endometriosis", "gynecology". Reviews, case reports and case series with less than 10 patients were excluded, obtaining 26 articles for the qualitative synthesis (Table 1,Ref. [19–31] ; Table 2, Ref. [17,32–43]). PRISMA guidelines were followed during the selection process [44,45] (Fig. 1).

3. Feasibility and Safety

Feasibility and safety of a new surgical technique are the first aspects to take into account while assessing its validity. Different articles advocate to this purpose, with either retrospectively and prospectively designed studies. The Laparoscopy vs. Robotic Surgery for Endometriosis (LAROSE) trial [19] is the first multicenter randomized controlled trial comparing laparoscopic vs robotic surgery for endometriosis at all stages. The study population was recruited between three centers in USA and surgeries were performed by experienced surgeons in each center. Women were randomly assigned to the laparoscopic or to the RALS arm. All patients were affected by endometriosis but those cases with need for bowel resection and/or ureteral reanastomosis were excluded from the study. RALS and conventional laparoscopic procedures showed no difference as for operative time, with mean operative time being 106.6 $\pm$ 48.4 minutes and 101.6 $\pm$ 63.2 minutes respectively. Differences were not found neither in terms of blood loss and operative and postoperative complication when adjusted for the number and type of procedures performed, nor in terms of rate of histologic confirmation of endometriosis.

A large retrospective single center cohort study has been published by Huang *et al*. [32] demonstrating the feasibility of robotic single-site surgery for treatment of endometriosis at all stages. Data from 334 surgeries were analyzed along with perioperative outcomes. At least one additional port was placed in 41 (12%) patients, in cases of more complex lesions that demanded greater precision of instruments and a wider surgical field. The median estimated blood loss was very low (25–50 mL) and lower than that of traditional RALS and conventional laparoscopy [19,33], suggesting that robotic single site laparoscopic surgery does not increase the amount of blood loss. As for the complication rate, 20 (6%) postoperative complications occurred of which only 2 (0.6%) of grade III by the Clavien-Dindo classification [46,47]; the other 4 complications were grade I or II. This rate is similar to that reported for traditional RALS and conventional laparoscopy [19,33,47–50]. No umbilical hernia due to large umbilical incision was reported in this cohort.

Furthermore, other studies adressed the effectiveness of RALS treatment specifically in patients with severe endometriosis, defined as stage III or IV of the American Society for Reproductive Medicine (ASRM) [51]. Two retro-

Table 1. Studies with comparison of robotically-assisted laparoscopic surgeries and conventional laparoscopic surgeries for endometriosis.

Authors	Year of publication	Reference n.	Study design	n° of patients	Type of endometriosis	Complications	Folow-up
Dulemba JF *et al.*	2013	[27]	Retrospective cohort study	180 RALS, 100 LPS	all	RALS 1.1% (1 intraoperative + 1 C-D grade I) vs LPS 0%	2 weeks
Nezhat FR *et al.*	2014	[20]	Retrospective cohort study	32 RALS, 86 LPS	ASRM stage III–IV	RALS: 10% C-D grade II (3), 6.2% C-D grade 3b (2) vs LPS: 5.8% C-D grade II (5), 1.2% C-D grade 3b (1)	1 month
Nezhat CR *et al.*	2015	[21]	Retrospective cohort study	147 RALS, 273 LPS	ASRM stage III–IV	RALS: 0% vs LPS: 0% (only C-D grade III and IV considered)	N/A
Le Carpentier M *et al.*	2016	[26]	Retrospective cohort study	15 RALS, 22 LPS	bladder endometriosis	RALS: 7% conversion (1), 27% C-D grade II (4), 33% C-D grade III (5) vs LPS: 0% conversion, 18.2% C-D grade II (4), 14% C-D grade III (3)	1, 3, 6, 12 months
Soto E *et al.*	2017	[19]	Randomized controlled trial	35 RALS, 38 LPS	all	RALS: 28.5% C-D grade II (10) vs LPS: 36.8% C-D grade II (14)	6 weeks, 6 months
Mosbrucker C *et al.*	2017	[28]	Randomized controlled trial	50 RALS, 48 LPS	all	N/A	N/A
Moon H *et al.*	2018	[29]	Retrospective cohort study	68 RALS, 52 LPS	all	RALS: 0% vs LPS: 0%	6 months
Vizzielli G *et al.*	2020	[22]	Retrospective multicenter cohort study	20 RALS, 27 LPS	ASRM stadio III–IV	RALS: 5% C-D grade II (1), 5% C-D grade IIIb (1) vs LPS: 7.4% C-D grade II (2) e 3.7% C-D grade IIIb (1)	N/A
Le Gac M *et al.*	2020	[23]	Prospective cohort study	23 RALS, 25 LPS	colorectal endometriosis	RALS: 9% C-D grade III (2), 4% C-D grade IV (1) vs 0% C-D grade III (0), 16% C-D grade IV (4)	N/A
Lee HJ *et al.*	2020	[30]	Retrospective cohort study	40 RALS, 54 LPS	ovarian endometriosis	N/A	3, 6 months
Gupta N *et al.*	2020	[31]	Retrospective cohort study	36 RALS, 49 SSRALS, 44 LPS	all	RALS: 8.3% intraoperative (3), 0% postoperative vs SSRALS 4% intraoperative (2), 4% postoperative (2) vs LPS 2.3% intraoperative (1), 2.3% postoperative (1)	N/A
Di Maida F *et al.*	2020	[25]	Retrospective cohort study	46 RALS, 28 LPS	urinary tract endometriosis	RALS: 4.3% C-D grade II (2), 2.1% C-D grade III (1) vs LPS: 14.2% C-D grade II (4), 3.5% C-D grade III (1)	30 months
Raimondo D *et al.*	2021	[24]	Prospective multicenter cohort study	22 RALS, 22 LPS	colorectal endometriosis	RALS, 4.5% C-D grade I (1), 4.5% C-D grade II (1), 9% C-D grade III (2) vs LPS 4.5% C-D grade I (1)	12 months

RALS, robotically-assisted laparoscopic surgery; LPS, laparoscopy; SSRALS, single-site robotically-assisted laparoscopic surgery; ASRM, American Society for Reproductive Medicine; C-D, Clavien-Dindo classification; N/A, not applicable.

Table 2. Studies with assessment of robotically-assisted laparoscopic surgeries for endometriosis without comparison to conventional laparoscopy.

Authors	Year of publication	Reference n.	Study design	n° of patients	Type of endometriosis	Complications	Folow-up
Magrina JF *et al.*	2015	[33]	Retrospective cohort study	493	ASRM stage III–IV	0.6% conversions (3), 0.4% intraoperative (2), 2.8% C-D grade II (14), 1% C-D grade IIIb (5)	42 days
Abo C *et al.*	2017	[36]	Prospective cohort study	35	DIE	3% C-D grade IIIb (1)	24 ± 8 months
Ercoli A *et al.*	2017	[37]	Prospective cohort study	31	colorectal endometriosis	3% C-D grade IIIb (1), 6% C-D grade I (2)	3, 6, 12 months
Tamura VG M *et al.*	2018	[34]	Retrospective cohort study	274	all + other gynecological diseases	1.1% conversions (3), 0.8% C-D grade III (2)	N/A
Riley K *et al.*	2018	[40]	Randomized controlled trial	73	superficial endometriosis	N/A	6 , 12 months
Giannini A *et al.*	2018	[17]	Retrospective single center case series	31	urinary tract endometriosis	16.2 C-D grade III (5)	3, 6 months
Poujois J *et al.*	2019	[35]	Retrospective single-center case series	20	all	5% conversions (1), 5% C-D grade I (1), 5% C-D grade IIIa (1)	N/A
Graham A *et al.*	2019	[38]	Retrospective single-center case series	15	colorectal endometriosis	26.6% C-D grade III (4)	1, 3 months
Diez SP *et al.*	2019	[41]	Experimental	19	not specified	N/A	N/A
Zhang Y *et al.*	2021	[42]	Retrospective case series	33	all	3% conversions (1), 12.2% C-D grade II (4)	3 weeks
Philip CA *et al.*	2021	[39]	Retrospective multicenter cohort study	232	urinary tract endometriosis	18% C-D grade I (44), 7% C-D grade III (16), 0.4% C-D grade IV (1)	3 months
Huang Y *et al.*	2021	[32]	Retrospective cohort study	334	all	5% C-D grade III (18), 1% C-D grade IV (2)	N/A
Delgado SI *et al.*	2021	[43]	Restrospective cohort study	158	all	N/A	3 weeks

ASRM, American Society for Reproductive Medicine; DIE, Deep Infiltrating Endometriosis; C-D, Clavien-Dindo classification; N/A, not applicable.

spective cohort studies compared RALS and conventional laparoscopy in the treatment of advanced endometriosis. Nezhat FR. *et al*. [20] compared operative time, blood loss, intraoperative and postoperative complications and hospital stay in a cohort of 32 patients treated with RALS and 86 patients treated by conventional laparoscopy. They found no differences in terms of blood loss, complications and hospital stay; RALS showed longer operative time than laparoscopy but after stratification for patient's BMI, the difference in operative time remained significant for obese patients only with RALS procedures being longer than conventional laparoscopy. In this study patients were not randomly assigned to one or other technique but the choice was made according to surgeon's preference. Therefore, the apparent longer operative time for RALS procedures in obese patients could be the result of a selection bias and points out the need for cohort randomization in this kind of comparison. Nezhat CR. *et al*. [21] considered the same perioperative outcomes in a cohort of 147 patients undergoing RALS and 273 patients undergoing conventional laparoscopy for advanced endometriosis; the patients were assigned to RALS or laparoscopy based on the availability of the operating room only, so that no surgeon's choice bias was present. There were no significant differences in blood loss or complication rate between the two groups but RALS operative time was significantly longer (mean 196 minutes) than laparoscopy group (mean 135 minutes); also, hospital stay was longer for RALS patients than laparoscopy patients. Studies on surgical treatment of other gynecological diseases evidence this discrepancy in operative time between robotic-assisted surgeries and laparoscopy with longer operative time using RALS [52–54] but this is not consistent with all the literature. Magrina *et al*. [33] describe the surgical treatment of endometriosis stage III and IV in 493 patient, 331 undergoing RALS and 162 undergoing conventional laparoscopy. After multivariate analysis considering age, blood loss and number of procedures performed, operative time was shorter for RALS than laparoscopy. Moreover, the authors concluded that the type of procedure, RALS or laparoscopy, do not influence hospital stay or complication rate. A longer operative time is the only significant variable influencing a higher complication rate and longer hospital stay. Thus, implying that the implementation of time-saving strategies, such as the standardization of surgical steps in endometriosis surgery, either laparoscopic and robotic, would be able to reduce the complication rate and improve outcomes.

Complication rates have been demonstrated to be comparable for both techniques, either when assessing all types of endometriosis and when evaluating severe endometriosis (ASRM stage III–IV) [19,22].

Accounting for feasibility of the procedure, all selected studies describe RALS for endometriosis treatment as feasible and effective. Only one study [21] highlights the limits of RALS while approaching cases of extrapelvic endometriosis such as diaphragmatic endometriosis, because of the need for different trocar positioning and difficult robotic branches mobilization. Overall, available literature is not unanimous regarding operative time in RALS procedures compared to conventional laparoscopy and it seems reasonable that the differences between the experiences are due to the wide variety of surgical expertise and procedures implemented which are hardly comparable between studies.

4. Learning Curve

The majority of the studies included in this review reports the results of surgical procedures implemented by experienced surgeons in the field of RALS. This aspect ensures the possibility to compare results between centers but it does not provide the fundamental information regarding the learning curve of the new technique. Indeed, feasibility and safety are the first aspect to consider, but the prospect of an effective surgical approach which is also easy and fast to learn is even more alluring. On one hand, the learning period for laparoscopic complex procedures such as radical hysterectomy and lymph node dissection is long, accounting for at least 40 cases needed to achieve a turning point in the operative duration and complication rates [55]. On the other hand, RALS in gynecology has been reported to be characterized with a shorter learning curve, with 12 to 18 procedures needed to gain equivalent expertise [56].

Gomes *et al*. [34] compared perioperative outcomes of patients operated by experienced and beginner robotic surgeons assisted by an experienced proctor. In this retrospective study, 274 different kind of gynecological robotic surgeries were analyzed, being endometriosis treatment the most frequent (57%). No difference in terms of need for transfusion, complications rates and conversion rates was observed between the two groups, pointing out the safety of introduction of RALS procedures in a less experienced team with the supervision of a proctor.

The learning curve of RALS for deep endometriosis treatment is addressed by a single-center retrospective study from Poujois *et al*. [35]. In this study, 20 patients underwent a RALS procedure for eradication of endometriosis performed by gynecologysts who were trained for laparoscopic complex gynecological procedures but not for DIE surgery nor for robotic-assisted procedures. Perioperative outcomes were evaluated and compared to the available literature on RALS for DIE. According to operative time, blood loss, performed procedures, complications and hospital stay, no significant differences were identified, meaning that the learning phase for RALS in the study setting had no impact on perioperative outcomes. This could imply that it is easier to approach to RALS when having already some laparoscopic experience. However, it does not demonstrate that RALS for the treatment of DIE is actually the easier route for the surgeon.

In order to effectively compare the learning curve of the two surgical approaches in the treatment of DIE, ran-

domized studies comparing the two techniques performed by surgical teams with little experience either in conventional laparoscopy and robot-assisted procedures would be needed.

5. Deep Endometriosis

Different studies investigated the role of robotic-assisted surgery specifically for the treatment of deep endometriosis, which is the type of endometriosis mostly correlated with severe symptoms and more complex surgical procedures [57]. In 2017, Abo *et al*. [36] published a prospective cohort study assessing the feasibility of RALS for the treatment of deep endometriosis localizations, trying to outline benefits and limits. Thirty-five patients underwent a RALS procedure for different DIE lesions, including colorectal and urinary tract nodules. Effectiveness of the treatment was evaluated by the presence of recurrence at one-year follow up and by preoperatively and postoperatively administering questionnaires on bowel function and quality of life. Overall, no recurrence was found at follow up and self questionnaires revealed a significant decrease in pain symptoms in most patients. Two case series reported a single institution experience on colorectal endometriosis treated robotically. The first from Ercoli *et al*. [37] evaluated perioperative outcomes in 35 patients who had undergone nerve-sparing nodulectomy of a rectosigmoid endometriotic nodule. They define robotic nodulectomy as a safe and feasible procedure, independently from the nodule's dimension, thanks to the precision obtainable by combining the 3D vision with freeness of movement of robotic instruments. On the other hand, Graham *et al*. [38] describe the implementation of robotically-assisted segmental resection and disk resection in 15 patients with colorectal endometriosis. In their experience the procedure was feasible but burdened by a substantial number of post-operative pelvic abscesses (33%), probably because an extensive shaving and disk excisions may have led to diffuse tissue devitalization. Two more recent studies compared laparoscopic and robotically-assisted treatment of colorectal endometriosis. A prospective cohort study by Le Gac *et al*. [23] reports similar perioperative outcomes in 23 patients treated with RALS and 25 patients treated by conventional laparoscopy except for longer operative time in RALS group, defining RALS an adequate alternative to laparoscopy for the treatment of deep endometriosis. In a prospective multicenter observational study, Raimondo *et al*. [24] compared perioperative outcomes and endometriosis-related symptoms trend in 44 patients treated for rectosigmoid endometriosis, with 22 patients undergoing RALS and 22 patients undergoing conventional laparoscopy. Operative room occupancy time was the only parameter which differed between the two groups but operative time (from skin incision to suture), blood loss, complication rate and hospital stay was comparable. All patients in both groups reported significant improvement in pain symptoms 12 months after surgery.

All studies assessing robotic surgery for urinary tract endometriosis have a retrospective design. Giannini *et al*. [17] report a series of 31 cases of robotically-assisted eradication of ureteral endometriosis with a follow up period of 3 and 6 months. They conclude that RALS allows complete radical excision of ureteral endometriosis even in complex cases, but with not negligible rate of urinary tract complications (16%). Similar results were shown by the work of Di Maida *et al*. [25] in 2020 and Philip *et al*. [39] in 2021. The only study comparing robotically-assisted procedures with conventional laparoscopy in the eradication of urinary tract endometriosis is a retrospective cohort study from le Carpentier *et al*. [26]. The authors describe 37 cases of bladder endometriosis, 15 treated by RALS and 22 treated by conventional laparoscopy. Their results show no differences in terms of blood loss, operative time and hospital stay between the two techniques; complication rate was higher for the RALS group (33% vs 14%) but RALS group included patients with bigger and deeper lesions, with median size of resected lesion being 30 mm for RALS group and 23.5 mm for laparoscopy group. The specific advantage of the use of RALS in urinary tract endometriosis surgery is the improved degree of freedom of movements even in small spaces such as the prevescical, paravescical and pararectal spaces compared to those allowed by conventional laparoscopy. However, whether robotic assistance may improve the outcomes of patients with urinary tract DIE remains to be explored, especially when surgery should gain a functional outcome such as procedures of ureteral anastomosis or ureteral reimplantation.

6. Quality of Life

Improvement of quality of life must be the end goal for each and every surgery aiming to treat endometriosis [58]. Quality of life is a less quantitative and more qualitative parameter, thus it is more difficult to assess in an objective manner. As a matter of fact, very few of the available studies on endometriosis surgery by RALS address the topic. In a prospective cohort study [36], 35 patients undergoing RALS for treatment of deep endometriosis were administered pre- and postoperatively questionnaires evaluating quality of life and digestive function. Particularly, gastrointestinal symptoms were in detail evaluated through Gastrointestinal Quality of Life Index (GIQLI) [59], the Knowles-Eccersley-Scott-Symptom Questionnaire [60], the Fecal Incontinence Quality of Life Index [61] and the Bristol stool scale [62]. Also, endometriosis-related pain symptoms such as dysmenorrhea and dyspareunia were evaluated using an 11-point Visual Analogue Scale (VAS). Self questionnaires revealed a significant decrease in pain symptoms related to endometriosis in most patients and the values of several items of gastrointestinal standardized questionnaires were significantly improved. The LAROSE trial [19] measured quality

of life changes before and after surgery by administering the patients the 12-Item Short Form Health Survey (SF-12) [63] and the Endometriosis Health Profile (EHP-30) [64] questionnaires at baseline and 6 weeks and 6 months after surgery. The results are particularly interesting because for the first time quality of life after endometriosis-surgery is compared between conventional laparoscopy and robot-assisted procedures. According to the SF-12 questionnaires, there were no differences in scores between the two techniques and between baseline, 6 weeks and 6 months. On the other hand, improvement was shown compared with baseline according to EHP-30 questionnaire results, which investigated, pain scores, control/powerlessness, emotions, social support, self-image, work, children, sexual intercourse, medical profession and treatment. No statistical differences were found between the laparoscopy and the RALS group.

One other study investigated the effect of surgery for deep endometriosis, comparing conventional laparoscopy with robot-assisted laparoscopy [24]. Endometriosis-related symptoms were pre- and postoperatively evaluated with an 11-item Visual Analogue Scale (VAS). Consistent with the other studies available, all patients in both groups reported a significant improvement of pain and bowel symptoms after surgery at 12-months follow up.

A recent study investigated one other aspect which could be included in a wide meaning of quality of life, the cosmetic satisfaction after surgery [65]. The authors report the results of a survey on 64 patients who underwent either robot-assisted or conventional laparoscopy for benign gynecological disease. Every skin incision was closed in the same manner and by the same surgeon but the position and width of the incisions were different according to the technique used. According to the results of the survey, the cosmetic satisfaction rate was higher in the laparoscopic group than in the robotic group. Obviously, cosmetic satisfaction cannot be the decisive parameter to choose one surgical route or another. Nevertheless, site of skin incision and possible esthetic concerns should be part of the preoperative counseling with the patient.

7. Conclusions

Robotic surgery has spread rapidly in the last decade. A 2020 cohort study published on Journal of the American Medical Association (JAMA) [66] reports that the use of robotics in general surgery increased from 1.8% in 2012 to 15.1% in 2018, and for certain procedures, the magnitude of the increase was greater. This trend is generalized even in other specialties, particularly urology and gynecology.

In the context of a generalized need of optimization: of resources, of manpower, of money, of therapy, it is topical to assess whether a specific treatment is not only effective and safe but also timely indicated, widely available and cost-worthy. Surprisingly, more than two decades after the first robotic platform was introduced to assist laparoscopic surgery, this kind of evaluation regarding endometriosis surgery is still far from being easy and handy. On one hand, the available literature demonstrates without a doubt the feasibility of endometriosis eradication via robotically-assisted laparoscopy. Also, safety of RALS for endometriosis could be cautiously assumed from the studies with widest casuistry, which show comparable complication rates and perioperative outcomes between conventional laparoscopy and RALS. There are very few studies which report a slightly higher complication rate for RALS procedures, especially for deep urinary tract endometriosis; anyway, the comparison of the results from all studies is difficult because of the extreme variability in design, the low number of cases reported and the lack of standardization of the surgical technique for robotic procedures. Indeed, more reliable evidence would be gained from studies with largest cohorts and well standardized clinical parameters and technical steps for the procedures.

On the other hand, costs related to the use of robotic surgeries instead of laparoscopy should be thouroughly taken into account. Health care costs for endometriosis are substantial, with 29% of the cost attributed to the surgical procedure and 18% to hospitalization [67]. Whether the advantages related to robotic procedures, such as shorter operative time for some studies, faster recover and shorter hospital stay would compensate the increase in the cost of the surgical procedure itself, is yet to be determined. However, this evaluation would constantly need to be updated on the available technology, which is tending towards easier systems with faster docking and instrument interchange. Moreover, the effort in developing new robotic systems has been huge in the last few years, with new platforms trying to overcome some limits of the already available systems. Indeed, also the competition between brands is a good premise to speed up technological advances and bring down the costs associated to robotic surgery. Besides, technical innovations are going to improve safety and effectiveness of procedures, by providing systems able to reduce the complication rate and to speed up the learning curve, such as the integration of preoperative imaging with the surgical field (augmented reality).

Undoubtably, there is an impellent need for randomized studies with comparison of the most recent available technologies in a parametrizable manner, in order to found the ground on which standardized guidelines could be made. However, as it is known, innovation cannot be efficient at first and great innovations are the result of implementation and correction of small everyday changes. Robotic technology applied to laparoscopy in the treatment of endometriosis could be seen as an effective and safe alternative to the conventional treatment but also as a promising tool for future achievements.

Author Contributions

All authors named on this submission made substantial contributions to the study. Material preparation and data collection were made by LCM, DR and PC, analysis was made by ALM and RS. The first draft of the manuscript was written by CA and LCM. GG and all authors commented on previous versions of the manuscript and approved the final manuscript.

Ethics Approval and Consent to Participate

Not applicable.

Acknowledgment

Not applicable.

Funding

This research received no external funding.

Conflict of Interest

The authors declare no conflict of interest. GG is serving as one of the Guest editors of this journal. DR and PC are serving as one of the Editorial Board members of this journal. We declare that GG, DR and PC had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to CI.

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