ORIGINAL RESEARCH ARTICLE

New technologies in the surgical management of endometriosis

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ABSTRACT

Introduction: Endometriosis is a very common disease that affects up to 10% of the female population. Although medical therapy represents the first-line treatment for endometriosis, it does not always manage to control symptoms. Laparoscopy represents the standard surgical treatment in endometriosis. Robotic-assisted laparoscopy is an innovative mini-invasive surgical technique. Its application in gynecological surgery and in endometriosis has increased in the last decade. Our purpose is to offer an overview of the role of robotic-assisted laparoscopy in the surgical treatment of endometriosis.
Methods: We evaluated studies dealing with the new technique in surgery for endometriosis with a focus on robotic surgery. We performed a compressive literature research on PubMed and the Cochrane Library in December 2022.
Expert opinion: Robotic-assisted surgery is a feasible and safe approach to endometriosis surgery and is super-imposable to laparoscopy in terms of complication rate, blood loss, hospitalization, and long-term improvement of symptoms.
The effect of robotic-assisted surgery on operative time is still contradictory and needs to be further investigated. Robotic-assisted laparoscopic surgery can provide particular benefit in the management of women with severe endometriosis secondary to its advantage in surgical precision and ergonomics.
Indocyanine green fluorescence angiography could be useful to assist in the vascularization of ureters and bowel anastomosis, to prevent postoperative complication and leakage.

Keywords: Deep endometriosis, Endometriosis, Indocyanine green, Laparoscopy, Robotic surgery, Surgical treatment

Introduction

Endometriosis is a chronic disease characterized by functional endometrial-like tissue located outside the uterus (1,2). Endometriosis manifestations could range from asymptomatic cases to severe chronic diseases characterized by pelvic pain, dysmenorrhea, dyspareunia, neurologic pain, dyschezia, dysuria, and infertility (1-3). Despite its high prevalence, the severity of symptoms, and its high socioeconomic impact, the real incidence of endometriosis is unknown (1,2). It is estimated that this condition affects 2%-10% of reproductive age women and up to 50% of infertile women. Moreover, a significant delay between the onset of first symptoms and a reliable diagnosis has been demonstrated (2).

Endometriosis can be divided into superficial peritoneal implants, ovarian endometriomas, and deep infiltrating endometriosis (DIE), in which ectopic implants infiltrate the peritoneum >5 mm (4). Endometriotic cells preserve the capability of response to sex hormones, causing cyclic bleedings, chronic inflammation, adhesion formation, and anatomic distortion (1).

Treatment for endometriosis should be customized according to symptoms, the stage of the disease, and the desire of pregnancy. In asymptomatic patients with an incidental diagnosis, periodic follow-up with ultrasound monitoring can be considered (2).

Medical therapy should always be used as the first line in endometriosis treatment. The current recommendation includes combined hormonal contraceptive and progestogen; meanwhile gonadotropin-releasing hormone (GnRH) agonist, GnRH antagonist, and aromatase inhibitors are considered as a second-line medical treatment. Danazol is no longer described as a medical treatment for endometriosis-associated pain (2).

Surgery for endometriosis may include complex procedures that can involve significant complications (3,5). Surgical approach should be considered only in select cases, as in refractory pain or symptoms that don't respond to medical therapy and significantly impact the quality of life (QoL) of patients, in case of organ dysfunction or obstruction, or risk of malignancy (2). In these patients, surgery results in a significant improvement in pain and QoL (6). The complete excision of endometriosis offers good long-term symptomatic relief, especially in cases with severe or debilitating symptoms (7,8).

The impact of surgical treatment on infertility is still debated (2,9). Surgery may have a beneficial impact on the chance of spontaneous conception (10), although surgery should be considered cautiously, secondary to the risk of damage to ovarian reserve, in particular among patients with endometrioma. In the absence of other contraindications to surgery, in case of infertility, assisted reproductive technology is generally preferred as the first-line treatment (2,10,11).

Mini-invasive surgery represents the standard surgical treatment in endometriosis, secondary to the advantages in visualization, shorter hospital stays, faster recovery, and better cosmetic results compared to laparotomy (2,3).

Robotic-assisted laparoscopy and endometriosis

Robotic-assisted laparoscopy (RAL) is an emerging innovation in mini-invasive technique, developed in order to overcome some limitation of standard laparoscopy (LPS) (12). RAL guarantees better surgical field visualization through high-resolution 3D view, better mobility thanks to the wrist-like motion of the robotic arms, a tremor-free handling, direct control of surgeons' three or four arms, and an improved ergonomics. This technique increases the abilities in LPS suturing, knot-tying, lysis of adhesions, and retroperitoneal exploration (12-16). Moreover, the higher degree of freedom in motion and the possibility of working in a parallel console facilitate training of the less expert surgeons and reduce the learning curve of RAL compared to LPS (12,13,17). Practically, robots make LPS easy.

Recently, the use of RAL in gynecological surgery has increased. Nevertheless, RAL presents significant limitations in the lack of tactile feedback (14). One of the biggest limitations of RAL is the significantly higher cost compared to LPS, which restricts its application, in particular, easy procedure (12,15,18). Regarding endometriosis surgery, there are no data comparing RAL to LPS in ovarian endometriomas. The procedure is easily performed by LPS surgery; therefore, the use of RAL would not be a cost-effective option and it should not be recommended (13).

Surgery for DIE may include complex procedures such as extensive adhesiolysis, ureterolysis, partial bladder or bowel resection, ureteral resection, and reanastomosis (Fig. 1) (3). DIE treatment needs high surgical skills and wide experience to achieve the radicality and to preserve, as much as possible, the vascularization and the neurovegetative function of the pelvic organs. Major complications from surgery for deep endometriosis can occur in 3.9% of cases (3).

Many studies have shown that RAL is a feasible and safe alternative to LPS for the treatment of endometriosis (5,18-21). A systematic review from Restaino et al (5) and the prospective randomized trial LAROSE (19) confirmed that RAL
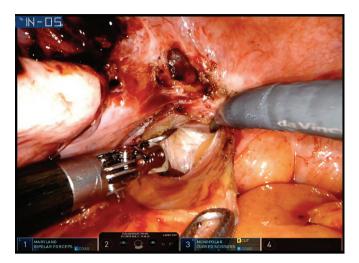

Fig. 1 - Robotic-assisted left ureterolysis with DaVinci® Xi in a patient with left uterosacral deep infiltrating endometriosis nodule.

and LPS are superimposable in terms of blood loss, complication rate, hospital stay, and both significantly improved pain and QoL after intervention. One of the major concerns about RAL is the possible increase in operative time compared to LPS (5,20,22). Docking time represents critical factors in determining the operation time (17). Restaino et al (5) reported an increase of operative time in RAL, despite the elimination of docking time, although the authors highlight that none of the study analyzed mentioned the learning curve for RAL procedures. The authors hypothesized that surgeon expertise with RAL could explain the increase in operative time (5).

Raimondo et al (23) compared perioperative outcome in a multicentric prospective study of 44 cases with stage III to IV endometriosis eradication performed by two surgeons proficient in both LPS and RAL. Data showed no significant difference between the two groups regarding operative time, confirming the importance of an adequate training of the operator approach to this innovative surgical technique.

Moreover, in a large retrospective study by Magrina et al (24) of patients affected by severe endometriosis, the authors observed that RAL results in shorter mean operative time, after adjusting the findings for age, blood loss, and number of procedures per patient.

It is worth to notice that the most encouraging result has been observed in advanced stage endometriosis, a procedure that requires demanding surgical effort (5,23-25). In previous published case series (26-28), RAL has demonstrated a high success rate in patients with stage IV endometriosis with colorectal involvement. Moreover, the postoperative follow-up showed a high pregnancy rate, significant decrease in pain symptoms, and a significant improvement of QoL (26-28).

In the case study from Ercoli et al. (29) on 33 women with retro-cervical endometriosis not involving rectal mucosa treated with RAL surgery, all nodules were shaved completely, independent by size, without major complications and with a low rate of segmental resection. Despite the large variety of procedures performed in this case series (ureterolysis, ureteral and rectovaginal nodule excision, bowel resection, uterosacral ligament resection, excision of posterior vaginal fornix

Fig. 2 - Opening of the right pararectal fossa with lateromedial approach to isolate a right uterosacral deep infiltrating endometriosis nodule with DaVinci® Xi.

and of peritoneal nodules), operative times were superimposable to those reported for LPS (Fig. 2) (29,30). The authors attributed the results to the highly precise surgery obtainable by RAL.

In two recent case studies (31,32), RAL has been successfully applied to nerve-sparing eradication of DIE, confirming the possible benefit of RAL in nerve-sparing surgery.

Indocyanine green in endometriosis

Endometriosis has a pleiomorphic appearance and it is not always easily recognizable (33). The use of indocyanine green (ICG) dye, as a support in surgery for endometriosis, has been spreading over the last few years. After its intravenous administration, using near-infrared (NIR) cameras, ICG can be perceived as the emission of fluorescent light (34). ICG may improve the diagnosis of endometriosis and allow an accurate intraoperative real-time assessment of tissue vascularization thanks to its ability to bind plasma proteins (33-35).

ICG fluorescence may be considered as a good diagnostic and screening test for DIE and peritoneal endometriosis. In a previous clinical trial, the use of NIR-ICG had high positive predictive value, specificity, negative predictive value, and sensitivity (36,37).

The Firefly™ technology is incorporated in the main robotic platforms and used for NIR imaging to detect injected ICG dye.

Levey was the first to use DaVinci® Si's fluorescent technology with ICG for increase in the detection and improvement of the surgical management of endometriosis (33). The use of ICG for detecting endometriosis in RAL has subsequently spread (38,39).

The ability of the 3D robotic Firefly™ imaging of DaVinci® Si Surgical System compared with 2D LPS on the detection of non-visible endometriosis has been investigated by Vizzielli et al (37). The authors observed higher sensibility and specificity in ICG fluorescence imaging in detecting endometriosis compared to simple white light imaging. The differences

did not reach statistical significance. However, in the trial by Jayakumaran et al (35), the performance of 3D robotic ICG fluorescence imaging in detecting endometriotic lesions had overcome the one of white light 3D robotic imaging and 2D LPS imaging.

ICG fluorescence is helpful in separating the endometriotic nodules from the healthy tissue. It has been used to guide shaving of bowel DIE nodules (40-42). In case of bowel involvement, ICG could be used to evaluate shaving feasibility and to better define the limits between nodule and healthy tissue (Fig. 3) (42).

Moreover, intravenous administration of ICG can be used to intraoperatively investigate ureteral perfusion to identify local ischemia (43). In case of bowel resection, it allows to assess the perfusion of the bowel, select the transaction line as well as evaluate the adequacy of the blood supply to anastomosis (Fig. 4) (44,45).
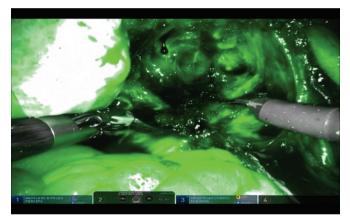

Fig. 3 - View of a rectal deep infiltrating endometriosis nodule (dark) after intravascular administration of indocyanine green dye with robotic Firefly™ imaging of DaVinci® Xi.

Fig. 4 - Use of indocyanine green dye to study the adequacy of vascularization prior to rectal resection with robotic Firefly™ imaging of DaVinci® Xi.

Previous retroperitoneal surgery, fibrosis, and the reduction of neoangiogenesis related to the use of estrogen-progestin or GnRH agonist may alter microcirculation of endometriotic lesions and could influence the success of this method (16).

Conclusion

RAL is a safe and feasible option and it might be considered an alternative to LPS in the surgical treatment of endometriosis. Some studies suggest that the use of RAL could cause an increase in operative use, although other trials demonstrate that operative time in RAL is superimposable to that of LPS if the procedure is performed by a trained and skilled surgeon.

Moreover, several studies had demonstrated the non-inferiority of RAL to LPS in terms of intraoperative and postoperative complication rate, blood loss, and hospital stay. Both the techniques significantly improve pain symptoms and QoL.

The advantages of the robotic platform are more pronounced in patients with severe endometriosis. In fact, the procedures required in these patients are more complex and the surgeon can benefit from the high surgical precision and decreasing fatigue of surgeons related to robotic platforms.

ICG fluorescence seems to be a good diagnostic test for guiding the surgeons to the approach to endometriosis. The data of the scientific literature are still not of adequate quality to recommend its systematic use. The use of ICG fluorescence for vascularization is fundamental for the choice of the correct site of transection to avoid failure of anastomotic site and leakages.

Disclosures

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