

Role of Laparoscopic Surgery in Deep Infiltrative Endometriosis: Review Article

Natthasiri Suwannarat, MD¹, Chainarong Choksuchat, MD²

¹ Department of Obstetrics and Gynecology, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla, Thailand

² Reproductive Medicine Unit and Gynecologic Laparoscopy, Department of Obstetrics and Gynecology, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla, Thailand

Endometriosis is a progressive medical condition that affects reproductive-aged women, usually presenting with pelvic pain and infertility. The deep infiltrative endometriosis, infiltrating the peritoneum of more than 5 mm, is found by pathology to be an active disease that involves the uterosacral ligaments, the retro-cervical area, the rectovaginal septum, the rectum, the vagina, and the bladder. The choice of therapy depends on the presentation and severity of the symptoms, the extended location of endometriotic lesions, and the fertility need. Laparoscopic surgery is a standard of clinical care for women with deep infiltrative endometriosis-related bowel endometriosis, severe pelvic pain, and infertility. Nevertheless, pre-operative mapping of the disease is difficult for accuracy planning, with bowel and urinary tract injuries being the major concern of surgical treatments. Thereby, a multidisciplinary laparoscopic approach, with radical laparoscopic surgery, plays an essential role for the treatment of deep infiltrative endometriosis.

Keywords: Deep infiltrative endometriosis, Endometriosis, Laparoscopy, Laparoscopic surgery

Received 17 April 2020 | Revised 23 July 2020 | Accepted 31 July 2020

J Med Assoc Thai 2020;103(12):1367-76

Website: <http://www.jmatonline.com>

Endometriosis is a progressive medical condition in women, which usually presents with pelvic pain and infertility⁽¹⁾. Endometrial glands and stroma are found outside the uterine cavity, and the disease is an estrogen-dependent disorder⁽²⁾. Endometriosis is based on the surgical visualization of the disease. This criterion has resulted in significant obstacles to determine the true prevalence of the disorder. The prevalence of pelvic endometriosis ranges from 6% to 10%. In general, the frequency of the female population in the USA who having pain, infertility, or both is at 35% to 50%⁽¹⁾. Differences in the prevalence of the disease vary by as much as 30 to 40 times. Coexistence of the endometriosis with

fibroid is approximately 10%^(1,2). In Thailand, the prevalence of pelvic endometriosis was reported to vary between 8.6% and 30.5%. However, this may be underestimated because the endometriosis may be coincident diagnosed with adenomyosis, uterine fibroid, or other benign ovarian cysts⁽³⁻⁵⁾.

Endometriosis is divided into three types, superficial, ovarian, and deep endometriosis. It is hypothesized that each of these has a different pathogenesis. Deep infiltrative endometriosis, that is infiltrating the peritoneum by more than 5 mm found by pathology is an active disease strongly associated with pelvic pain⁽⁶⁾. The prevalence was 25% of the patients with histologically proven endometriosis⁽⁶⁾. However, the exact incidence of deep infiltrative endometriosis is unknown, although this disorder seems to be frequently diagnosed.

Deep infiltrative endometriosis is divided into three subtypes, as shown in Figure 1.

Type I lesions appear in a conical shape, with the largest area lying in the peritoneal cavity. Type II lesions show adhesions, covering the deep lesion, that are the most typical lesions at the rectum, uterosacral ligaments, and the Douglas pouch. Type III lesions are defined as deep lesions, with their largest area occurring under the peritoneal surface. Deep

Correspondence to:

Choksuchat C.

Department of Obstetrics and Gynecology, Faculty of Medicine, Prince of Songkla University, Hat Yai, Songkhla 90110, Thailand.

Phone: +66-74-451201, **Fax:** +66-74-429617

Email: Chchaina@yahoo.com

How to cite this article:

Suwannarat N, Choksuchat C. Role of Laparoscopic Surgery in Deep Infiltrative Endometriosis: Review Article. *J Med Assoc Thai* 2020; 103:1367-76.

doi.org/10.35755/jmedassocthai.2020.12.11329

INFILTRATING ENDOMETRIOSIS

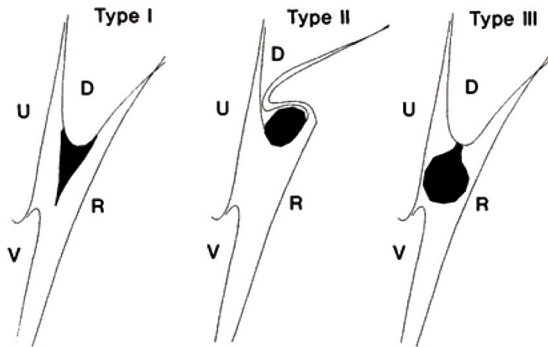


Figure 1. Shows 3 types of deep infiltrative endometriosis. U is uterus, pouch of Douglas is D, vagina is V and rectum is R⁽⁷⁾.

endometriosis type I is most frequently found in around 46% of the revised American Fertility Society (AFS) class II. On the contrary, Type III lesions are most frequently found in the revised AFS class I, which means that AFS classification poorly reflects the severity of deep endometriosis⁽⁷⁾.

Pathogenesis of deep endometriosis

The pathophysiology of deep endometriosis and the mechanisms of disease progression remain debatable. However, the highest frequency of histological patterns associated with deep infiltrative endometriosis is a mixed glandular pattern (46.9%) and an undifferentiated glandular pattern (33.5%). The resistance of endometrial tissue to suppressor effect of peritoneal fluid results in the undifferentiated endometriotic lesions, and allows these endometrial foci to infiltrate more deeply⁽⁸⁾. Furthermore, subjacent fibromuscular tissue occurs along with the loose connective tissue septa. The loose septa are completely filled with ectopic endometrial stromal cells. Estrogen receptors and progesterone do not only present in glands and stroma, but also appear in the smooth muscle component of the deep endometriosis⁽⁹⁾.

The expression of the estrogen receptor is obviously different in the deep infiltrative endometriosis. The 17 β -hydroxysteroid dehydrogenase, type 1 is responsible for E2 metabolism to lessen active estrone. It was found that the tissue concentration of E2 in deep infiltrative endometriosis increased, because of low levels of 17 β -hydroxysteroid dehydrogenase type 1, and the presence of progesterone resistance⁽¹⁰⁾.

The aggressive behavior of the deep infiltrative endometriosis may be described in several

mechanisms. Proliferation activity of endometriotic cells increases, whilst on the other hand, apoptosis or programmed cell death of endometrial tissue decreases. These phenomenon's may be associated with the activity of oxidative stress, such as reactive oxygen species (ROS), advanced oxidation protein product, and extracellular regulated kinase. Invasive mechanisms are visibly expressed, because of high concentrations of matrix metalloproteinases and activins in deep infiltrative endometriosis. Moreover, a very high expression of neuro-angiogenesis, such as nerve growth factors, vascular endothelial growth factors, and intercellular adhesion molecules, are also involved in the performance of deep infiltrative endometriosis⁽¹¹⁾.

Histology and clinical significance

The macroscopic appearances of the pelvic endometriosis are variable and include pigmented, non-pigmented, and subtle lesions. Pigmented endometriotic plaques typically contain hemosiderin-laden tissue, which are embedded, inactive endometriotic glands, and fibrous stroma. Non-pigmented endometriotic implants also contain active endometriotic glands and stroma.

Deep endometriosis is obviously excised with great care and prudence. Since the surgeons are continuously afraid of excising too deeply, histological specimens of very deep implants do not contain the accurate margin. The above issues correlated with 8% of reported cases, wherein, the margins of resection were not free from disease⁽⁹⁾.

Activity of endometriotic implants at different depths

Cornillie et al reported on the activity of endometriosis associated with the depth of implantation in infertility patients underwent laparoscopy. All tissue sampling was excised by CO₂ laser and confirmed diagnosis to be endometriosis by histology. They were defined to be 3 types of depths: superficial (less than 1 mm), intermediate (2 to 4 mm) and deep (equal or greater than 5 mm). They found that deep infiltration was observed in the pouch of Douglas (55%) and at the utero-sacral (34%) but absent from the ovarian fossa. Deep implants were also found to be active lesions more than superficial ones. Furthermore, deep implants also showed to be in phase with the endometrium in about 74% of the cases. This was the highest correlation with the endometrium along the menstrual cycle, when compared with superficial lesions. Finally, a depth of more than 10 mm was only

associated with patients having pain⁽⁹⁾.

Diagnosis

History taking and a meticulous physical examination are important for women suspected of endometriosis. Whilst further investigation by imaging can provide more information, a histologic study is needed for definite diagnosis of endometriosis.

Deep infiltrative endometriosis is strongly associated with symptoms of chronic pelvic pain, severe dysmenorrhea, deep dyspareunia, and non-cyclic pelvic pain⁽¹²⁾. Dyspareunia always has high specificity, but low sensitivity. One study reported that patients diagnosed with endometriosis, by histopathology, had a prevalence of 57% chronic pelvic pain, 55% deep dyspareunia, 48% cyclic intestinal complaints, 40% infertility, and 28% with incapacitating dysmenorrhea⁽¹³⁾. Consequently, several studies have reported the length of the time interval from onset of symptoms to diagnosis as 7 to 10 years in Europe, and 74% of patients received at least one false diagnosis^(14,15). Physical examination in endometriosis includes inspection of the vagina, using a speculum, as well as bimanual and rectovaginal palpation. Lesions located at the vagina, uterosacral ligament, and cul-de-sac may be detected by vaginal examination⁽¹⁶⁾. The sensitivity of detected deep infiltrating endometriosis by physical examination at uterosacral ligament was 73.5%. However, the sensitivity for diagnosis of endometriosis at rectovaginal (RV) septum is only 18.5%⁽¹⁷⁾. Poor accuracy for detection of RV septum is always associated with tortuous uterus. Eighty five percent of the lesions would be missed by inspection with a speculum⁽¹⁸⁾.

Investigation

A systematic review of the diagnostic value of transvaginal ultrasonography, for pre-surgical detection of bowel endometriosis, reported that sensitivity of diagnostic characteristics was 64% to 89% and specificity was 89% to 100%, LR+ 7.6 to 29.8, and LR- 0.1 to 0.4⁽¹⁹⁾. Transvaginal ultrasonography is useful for identifying and ruling out rectal endometriosis. Furthermore, bowel preparation prior to transvaginal ultrasonography showed a significant improvement in the diagnosis of deep endometriosis⁽²⁰⁾. A comparison between vaginal examination, transvaginal ultrasonography, rectal endoscopic sonography, and magnetic resonance imaging (MRI) revealed that MRIs are the best method to locate lesions of deep infiltrative endometriosis⁽²¹⁾.

MRIs are also useful to predict muscular infiltration in cases of bowel involvement of endometriosis. The “fan shaped” configurations on the MRI may facilitate in diagnosis and determine the extent of deep infiltrating of endometriosis at the muscular layer of the bowel. MRIs have a sensitivity of 100%, and specificity of 75%. Therefore, an MRI should be performed to evaluate symptomatic women before surgery⁽²²⁾. In addition, a colonoscopy is also useful to detect other pelvic pathology, including colorectal cancer or inflammatory bowel disease⁽²³⁾. However, a colonoscopy has limited value in the diagnosis of intestinal endometriosis, because of mucosal invasion of bowel endometriosis has proved to be less than 4% by histologic study⁽²¹⁾.

Treatment

Management of deep infiltrative endometriosis depends on the severity of symptoms, extension, and location of the endometriotic lesions, along with fertility needs⁽²⁴⁾. Pelvic pain and infertility are common presentations for women who have endometriosis. Severity of pain is related with location, depth of endometriotic implantation, and nerve invasion. Distortion of pelvic anatomy by adhesion and fibrosis forming can cause infertility, and the success of treatment is shown by clinical improvement, occurrence of complication, and recurrence rate.

Endometriosis-associated pelvic pain

Medical treatment is the primary choice for pelvic pain from deep infiltrative endometriosis⁽²⁵⁾. Currently, hormonal contraceptives, progesterone, gonadotropin-releasing hormone (GnRH) agonist, and aromatase inhibitors are in clinical use.

Ferrero et al⁽²⁶⁾ reported that oral contraceptives did not prevent the progression of bowel endometriosis. Nowadays, GnRH agonist is widely used to relieve pelvic pain associated with endometriosis. There was a case report showing the disappearance of an intestinal endometriotic polyp after three months of GnRH agonist treatment⁽²⁷⁾. However, long term use of GnRH agonist of more than six months should be used with caution because of an increasing risk of osteoporosis. The 3-month formulation of triptorelin and oral tibolone for 12 months also proved to be effective for rectal endometriosis. They reported that 72.2% of the patients were either satisfied or very satisfied with the treatment, however, long term hormonal use complication was not mentioned⁽²⁸⁾. Furthermore, hormonal therapies significantly decrease pain and

intestinal symptoms in patients with bowel stenosis at less than 60%, although this does not prevent the progression of bowel endometriosis⁽²⁹⁾. GnRH agonist cannot suppress all lesions of endometriosis due to the cells being inhomogeneous for each endometriotic foci⁽³⁰⁾.

Severe endometriosis with bowel involvement seems to be refractory to medical therapy⁽³⁰⁾. The intestinal invasion of deep infiltrative endometriosis is associated with bowel wall fibro-sclerosis, and progesterone resistant can cause an absence of response to hormonal treatment⁽³¹⁾. Several studies have considered laparoscopic colorectal resection for deep infiltrating endometriosis as the first-line treatment⁽³²⁻³⁴⁾, especially in cases where the bowel endometriosis is located at the appendicular, ileal, or caecal endometriosis, when there are growing lesions or no improvement of pain control after six months of medical therapy. Patients who fail to respond to medical treatment usually have larger rectosigmoid lesions of more than 3 mm, invasion of the muscularis propria layer⁽²⁵⁾, and stenosis of the bowel lumen greater than 60%⁽²⁸⁾.

Surgery

Surgical therapy is also widely used to treat pelvic endometriosis. The indications for surgery are usually for infertility or failure of medical treatment. There are two options for decision making. Firstly, conservative or definitive surgery, and secondly, laparotomy or laparoscopy. The goal of conservative surgery is to only remove some apparent endometriosis, but not to remove the deep endometriosis lesions and restoring normal pelvic organs. Conversely, radical surgery is the removal of all endometriosis lesions, ovaries, and sometimes, even the uterus.

In 2010, a systemic review described the indication of bowel resection for endometriosis, which was reported to be based on dimensions of the nodule being greater than 2 cm or 3 cm, with muscularis involvement, or based on the percentage of circumference involvement. However, the decision to perform a segmental bowel resection was made before surgery in only 14% of cases, with 86% of bowel resections emerging during surgery⁽³⁵⁾.

Deep infiltrative endometriotic patients should be treated by a multidisciplinary team, including gynecologists, colorectal surgeons, and urologists, for the best outcome.

The principles of surgery for severe endometriosis compose of exposition and adhesiolysis, precise and careful dissection, complete excision of the disease

whenever feasible or reasonable, and with respect to healthy tissue⁽³⁶⁾.

Types of surgery: laparotomy versus laparoscopy

Several studies reported that laparoscopy and laparotomy were comparable in the treatment of infertility and chronic pelvic pain associated with severe endometriosis^(37,38). The post-operative hospital stays were significant shorter in the laparoscopy group compared to the laparotomy group, at 1.7±1.4 days versus 6.0±1.2 days, respectively⁽³⁷⁾. The shorter post-operative hospital stay may represent less-pain and faster recovery in patients that underwent laparoscopic surgery. Post-operative adhesion formation, after laparoscopic surgery, for endometriosis was also less than after laparotomy⁽³⁹⁾.

Although, the recurrence rate is not significantly different in conservative laparotomy and laparoscopy, the risk of recurrence is higher in conservative surgery when compared with definite surgery^(37,38).

Conservative versus radical surgery

Several studies have encouraged the extensive laparoscopic excision of all endometriotic deposits as an effective therapy to relive pain, because of the pain symptoms being associated with the depth of infiltration⁽⁴⁰⁾. Nevertheless, radical surgery is often technically demanding, time consuming, and may be associated with significant surgical risks.

Jones and Sutton reported that 87.7% of the patients who were diagnosed stage III and IV endometriosis were satisfied or very satisfied with the treatment 12 months after laparoscopic ablative surgery⁽⁴⁰⁾.

On the other hand, some studies have reported that radical surgery is effective and shows a lower recurrence rate when compared to conservative surgery. Basaca et al reported that complete surgical excision of deep infiltrative endometriosis lesions is effective, with a statistically significant reduction in the intensity of all painful symptoms. Eighty-two percent of the patients reported being satisfactory. Furthermore, they reported postoperative improvements in their quality of life for up to 3.3 years without postoperative medical treatment, and 41.0% of the patients had a live birth after surgery⁽³⁸⁾. Additionally, radical surgery also improved the quality of life with a low incidence of complications without being life threatening^(41,42). Laparoscopic surgery of deep infiltrative endometriosis can cause rectal or ureteral injury in approximately 0.8% to

1.4% of the cases⁽⁴³⁾. A significant difference was observed in 36 months until symptom recurrence, showing that radical surgery significantly prolonged the recurrence-free period⁽⁴²⁾.

Additionally, there was evidence showing that surgical treatment of ovarian endometriosis had detrimental effects to ovarian reserves. The median anti-Mullerian hormone (AMH) level of surgery, for bilateral ovarian endometriomas, was lower when compared with surgery for unilateral ovarian endometriosis⁽⁴⁴⁾. The level of AMH may decrease up to 30% after excision of a unilateral endometrioma, and up to 44% after excision of bilateral endometriomas⁽⁴⁵⁾.

Surgical technique and effectiveness

Pre-operative

Bowel preparation with a low residual diet for three to four days before surgery is essential for pre-operative care because of the bowel endometriosis is usually associated with endometriosis at the US ligament⁽⁴¹⁾. In cases where bowel surgery is required, enema the night before surgery is recommended⁽⁴⁶⁾. Posterior deep infiltrative endometriosis is more common than anterior part. Uterosacral ligaments (USL) have also been proven as a frequent location for deep endometriosis^(21,41,46).

Conservative surgery

A randomized controlled trial suggested that laparoscopic uterosacral nerve ablation is not effective to relieve chronic pelvic pain from endometriosis⁽⁴⁷⁾. Moreover, laparoscopic resection of the uterosacral ligaments in women with endometriosis, and predominantly midline dysmenorrhea is not effective, because of deep infiltrative lesions not being removed⁽⁴⁸⁾.

Classical technique for radical surgery

The technical parameters are described as follows:

1. The first operation was adhesiolysis, which hindered mobilization of the bowel was freed. Commencing at the pelvic brim, followed by a direction from top to bottom, and laterally to medially^(49,50).

2. Both adnexa were mobilized by dividing their adhesions with the ovarian fossa. Temporarily suspension could be occurred using a 2/0 polypropylene non-absorbable suture, this was removed on day 3 after the surgery, according to the technique first described by Abuzeid et al^(51,52). These techniques

can improve access to the posterior cul-de-sac and may prevent the adhesion at ovarian fossa after the operation.

3. The sigmoid was detached and divided from the lateral wall. Mobilizing the bowel and adnexa helps to identify the left ureter, iliac vessel, and uterosacral ligament^(4,53).

4. The lesions were identified by careful intraoperative digital transvaginal, or transrectal palpation performed by the surgeon.

5. The systematic ureteral dissection was distally advanced towards the ureter's point of crossing with the uterine artery^(49,53).

6. The division of large uterine vascular branches was conducted.

7. An en-block resection of the invasive endometriosis was performed to mobilize the obliterated cul-de-sac of the pelvis^(49,53). All the abnormal tissue was removed, such as the proximal portions of both uterosacral ligaments, rectovaginal septum, and rectosigmoid lesions. However, it does not include the uterus when performing conservative surgery.

8. The retroperitoneal space was entered through a small peritoneal incision at a healthy area as close as possible to the nodule. The incision was closely made along the periphery of the lesion peritoneum of the ovarian fossa. The plane of dissection was caudally continued until the rectovaginal septum was reached⁽⁴⁹⁾.

9. The uterosacral ligament was subsequently divided at the point of its insertion to the uterine cervix⁽⁴⁹⁾.

10. Decisions as to whether to perform partial colectomy depend on the degree of vaginal induration caused by the nodule. An investigation was performed by the second assistant's vaginal finger, which served as a guide to limit the incision to a healthy plane in relation to the vaginal fornix.

11. The rectosigmoid was mobilized completely to access the lower mesorectum.

In 1991, Redwine and Sharpe⁽⁵⁴⁾ reported a technique for laparoscopic segmental resection of the sigmoid colon by using bipolar electrocoagulation and dissection scissors, following with closing of the bowel stump with a staple, for end-to-end anastomosis. The operation was successful, without immediate complications. The patient continued to do well with normal bowel function, and had good pain relief four months post-operation.

In 1996, Redwine et al⁽⁵⁵⁾ presented surgical steps in laparoscopically assisted transvaginal segmental

Table 1. Deep infiltrative endometriosis classification by anatomical position⁽⁴⁶⁾

Deep infiltrative classification (DIE)	Operative procedure
A: Anterior DIE	
A1: Bladder	Laparoscopic partial cystectomy
P: Posterior DIE	
P1: Uterosacral ligament	Laparoscopic resection of USL
P2: Vagina	Laparoscopically assisted vaginal resection of DIE infiltrating the posterior fornix
P3: Intestine	
• Solely intestinal location	
- Without vaginal infiltration (V-)	Intestinal resection by laparoscopy or laparotomy
- With vaginal infiltration (V+)	Laparoscopically assisted vaginal intestinal resection or by laparotomy
• Multiple intestinal location	Intestinal resection by laparotomy

Adapted from Wattiez et al 2013⁽⁴⁶⁾

resection of endometriosis at the rectosigmoid colon. The average operating time for laparoscopically assisted transvaginal bowel resection was faster than in the laparoscopic technique alone.

In 2000, Possover et al⁽⁵⁰⁾ showed a combined laparoscopic-vaginal technique for excision of a 2 cm deep endometriosis lesion of the rectovaginal septum by using two approach routes. Transvaginal approaches used Breisky specula for dissecting posterior fornix, and then an incision was made around the endometriotic nodule. Laparoscopic-abdominal was used for rectal transection to approach the rectovaginal space. The endometriotic lesion was excised with lower rectum (not more than 7 cm above the anus), after two routes reaching the endometriotic lesion at the rectovaginal space. Then trans-anal colorectal anastomosis was performed by connecting the stapling device with the anvil and firing the stapler. A minor anastomotic leakage was found in 5.8% of the patients after surgery, which was detected by sigmoidoscopy and later healed spontaneously.

In 2013, a retrospective study declared the surgery classification according to the invasion of the endometriosis as shown in Table 1. The classification of deep infiltrative endometriosis was presented as two groups, anterior compartment, which corresponded to deep bladder infiltrative endometriosis, and posterior compartment, which corresponded to USL, vaginal and intestinal disease⁽⁴⁶⁾.

The efficiency of the surgical treatment depended on the radicality of the excision coupled with the location of the deep infiltrative endometriosis. These factors influenced the choice of operating technique. Multifocality is the major characteristic of deep infiltrative endometriosis lesions, which is usually

associated with complex surgical procedures. It is essential to take this parameter into account when deciding on the surgical strategy⁽⁵⁶⁾.

Surgical technique for bowel endometriosis

In 2005, Possover et al⁽⁵³⁾ presented the Laparoscopic Neuro-Navigation (LANN) Technique to reduce postoperative functional morbidity in Laparoscopic Radical Pelvic Surgery. Intraoperative urodynamic testing was operated by a microtip rectal probe and a microtip transurethral catheter with a filling channel. The goal of a microtip probe was exposure from their origin to their anastomosis in the ipsilateral inferior hypogastric plexus. Resection of the parametria was radically performed in such a manner that the parasympathetic nerves were preserved. This technique provided satisfactory results by reducing the rate of postoperative bladder dysfunction to less than 1% of the patients.

In 2006, a prospective non-randomized study by Landi et al⁽⁵⁷⁾ suggested the value of this nerve-sparing technique. It included preserving the sympathetic and parasympathetic fibers of the lower mesorectum, the lower hypogastric nerves, the proximal part of the inferior hypogastric plexus, the pelvic splanchnic nerves, the cranial and middle part of the inferior hypogastric plexus in lower meso-rectal planes, and the caudad part of the inferior hypogastric plexus.

A systematic review reported the technique of bowel endometriosis surgery relied on location and the size of lesions. Segmental bowel resection and re-anastomosis were recommended when there were multiple lesions. A single lesion larger than 3cm was preceded by discoid bowel resection, while bowel shaving was used for a single lesion smaller than

3cm, being no deeper than the external muscularis layer. The major complications were bowel leakage and fistula. The colorectal anastomosis, when located less than 10 cm away from the anal verge, was an independent risk factor for the occurrence of anastomotic leaks⁽³⁵⁾.

In a recent review of the literature, Ruffo and Rossini concluded that laparoscopy in the management of deep infiltrative endometriosis with bowel involvement had an 8.7% overall complication rate. Major complications, such as anastomotic leakage was 25%, rectovaginal fistula was 18%, and intra-abdominal bleeding was 13% from the operation. Minor complications, such as transient bowel obstructions accounted for 9%, minor rectal bleeding was 4%, infections were 10%, urinary infections were 2%, and transient urinary retention was 4%⁽⁵⁸⁾.

Laparoscopic radical pelvic surgery, for deep invasion of bowel endometriosis, requires accurate pre-operative diagnosis of both size and location of deep infiltrative endometriosis. Furthermore, a multidisciplinary team and an experience surgeon are necessary factors for prevention of hypogastric nerve injury and complications of bowel injury⁽⁵⁹⁾.

Surgical technique for bladder endometriosis

Anterior deep infiltrative endometriosis, the treatment of bladder endometriosis depends on the age and reproductive intention of the patient. In postmenopausal patients, hormonal therapy with luteinizing hormone-releasing hormone analogs is reasonable. In women of reproductive age, who wished to become pregnant, surgical management is recommended⁽⁶⁾.

In 2000, vaporization with a CO₂ laser, to dissect the bladder from the surrounding tissue, was introduced. The defect was closed via a two-layer technique, then an injection of a solution of diluted methylene blue through the vesical catheter was conducted, to ensure the water tightness of the sutures. Bladder drainage was continued for 10 days, postoperatively⁽⁶⁰⁾.

In 2010, Kooor et al suggested that the complete excision of the endometriosis was the most important factor to resolve the symptoms, and to avoid recurrence. Partial cystectomy was designed for mucosal invasion⁽⁶¹⁾.

Laparoscopic partial cystectomy was suitable for a solitary bladder tumor that was distant from the bladder neck, the ureteral orifices, and the trigone, allowing a resection margin of 1 to 2 cm. A cystoscopy

at the end of the procedure was advisable to ensure watertight closure, and to check the ureteral orifices integrity⁽⁶²⁾.

On the contrary, Walid MS and Heaton RL reported that the operative laparoscopic cystectomy was not limited by location. Safety was increased with an initial cystoscopy, and placement of a double-J ureteral stent for identifying the urethral orifice. After lesions were identified, a harmonic scalpel and scissors dissection freed the scarred endometrial implant by safely excising a portion of the bladder⁽⁶³⁾.

In 2017, one author proposed the light-to-light technique, which combined conventional laparoscopy and simultaneous cystoscopy. Laparoscopic resection of the endometriotic nodule, together with the light-to-light technique, to preserve the bladder mucosa were safe and effective methods for partial cystectomy⁽⁶⁴⁾.

A laparoscopic approach has the difficulty to safely locate the ureteral distal tract and showed a high risk of iatrogenic ureteral injuries. Thus, laparoscopic treatment of bladder endometriosis required a combination of surgical treatments, by a gynecologist and a urologist, or an experienced laparoscopist⁽⁶⁵⁾.

Conservative surgery for fertility preservation

Hormonal treatment can be unacceptable in women desiring pregnancy. However, many studies describe that surgical treatment has more advantages than medical therapy.

A randomized controlled trial (RCT) to demonstrate the efficacy of laparoscopic surgery in the management of infertility-related endometriosis was performed by the Canadian Collaborative Group on Endometriosis⁽⁶⁶⁾. They suggested that minimal and mild endometriosis should be ablated or resected to enhanced fecundity in infertile women.

In women with minimal to mild endometriosis (rASRM classification), operative laparoscopy, including adhesiolysis, was effective in increasing pregnancy or live birth rates, compared to diagnostic laparoscopy⁽⁶⁷⁾.

On the other hand, a study suggested that bowel surgery for colorectal endometriosis seemed to be the riskiest procedure to enhance fertility. Therefore, infertile patients with intestinal endometriosis should be performed on exclusively by highly experienced surgeons⁽⁶⁸⁾.

A systematic review presented that surgery for deep infiltrative endometriosis improved spontaneous pregnancy rates and enhanced the success rate of assisted reproductive technology. Nevertheless, the operations for deep infiltrative endometriosis

were associated with a significant risk of major complications; therefore, patients should be referred to tertiary centers^(69,70).

Conclusion

Deep infiltrative endometriosis involves up to 12% of all women having endometriosis. The histopathology shows aggressive tissue invasion with fibromuscular reaction around the endometrial glands and stroma and demonstrates progesterone resistant. Therefore, deep infiltrative endometriosis, especially bowel endometriosis, seems to be refractory for medical therapy. Laparoscopy plays a major role in clinical care for women with deep infiltrative endometriosis-related bowel endometriosis, severe pelvic pain, and infertility. A multidisciplinary laparoscopic approach, with radical laparoscopic surgery is an effective treatment that improves all symptoms, including painful menstruation, non-menstrual pelvic pain, dyspareunia, and painful bowel movements. Laparoscopic surgery can improve quality of life, and significantly decreases the recurrence rate.

What is already known on this topic?

Removal excision of all endometriotic deposits is an effective therapy to relieve pelvic pain from deep infiltrative endometriosis.

What this study adds?

Laparoscopic surgery for deep infiltrative endometriosis gives distinguishable results in terms of pain relief, recurrent rate, and fertility when compared with conventional surgery. Furthermore, a laparoscopic approach provides less postoperative pain, shorter hospital stays, and less postoperative adhesion formation.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Martin DC, Hubert GD, Levy BS. Depth of infiltration of endometriosis. *J Gynecol Surg* 1989;5:55-60.
2. Viganò P, Parazzini F, Somigliana E, Vercellini P. Endometriosis: epidemiology and aetiological factors. *Best Pract Res Clin Obstet Gynaecol* 2004;18:177-200.
3. Naphatthalung W, Cheewadhanarak S. Prevalence of endometriosis among patients with adenomyosis and/or myoma uteri scheduled for a hysterectomy. *J Med Assoc Thai* 2012;95:1136-40.
4. Tanmahasamut P, Noothong S, Sanga-Areekul N, Silprasit K, Dangrat C. Prevalence of endometriosis in women undergoing surgery for benign gynecologic diseases. *J Med Assoc Thai* 2014;97:147-52.
5. Thailert S, Lumpikanon P, Songthamwatthana M. Endometriosis in Srinagarind hospital. *Srinagarind Med J* 1997;12:129-38.
6. Gordts S, Koninckx P, Brosens I. Pathogenesis of deep endometriosis. *Fertil Steril* 2017;108:872-85.e1.
7. Nisolle M, Donnez J. Peritoneal endometriosis, ovarian endometriosis, and adenomyotic nodules of the rectovaginal septum are three different entities. *Fertil Steril* 1997;68:585-96.
8. Kamergorodsky G, Ribeiro PA, Galvão MA, Abrão MS, Donadio N, Lemos NL, et al. Histologic classification of specimens from women affected by superficial endometriosis, deeply infiltrating endometriosis, and ovarian endometriomas. *Fertil Steril* 2009;92:2074-7.
9. Cornillie FJ, Oosterlynck D, Lauweryns JM, Koninckx PR. Deeply infiltrating pelvic endometriosis: histology and clinical significance. *Fertil Steril* 1990;53:978-83.
10. Dassen H, Punyadeera C, Kamps R, Delvoux B, Van Langendonck A, Donnez J, et al. Estrogen metabolizing enzymes in endometrium and endometriosis. *Hum Reprod* 2007;22:3148-58.
11. Tosti C, Pinzauti S, Santulli P, Chapron C, Petraglia F. Pathogenetic mechanisms of deep infiltrating endometriosis. *Reprod Sci* 2015;22:1053-9.
12. Koninckx PR, Meuleman C, Demeyere S, Lesaffre E, Cornillie FJ. Suggestive evidence that pelvic endometriosis is a progressive disease, whereas deeply infiltrating endometriosis is associated with pelvic pain. *Fertil Steril* 1991;55:759-65.
13. Bellelis P, Dias JA Jr, Podgaec S, Gonzales M, Barakat EC, Abrão MS. Epidemiological and clinical aspects of pelvic endometriosis—a case series. *Rev Assoc Med Bras (1992)* 2010;56:467-71.
14. Chapron C, Barakat H, Fritel X, Dubuisson JB, Bréart G, Fauconnier A. Presurgical diagnosis of posterior deep infiltrating endometriosis based on a standardized questionnaire. *Hum Reprod* 2005;20:507-13.
15. Hudelist G, Fritzer N, Thomas A, Niehues C, Oppelt P, Haas D, et al. Diagnostic delay for endometriosis in Austria and Germany: causes and possible consequences. *Hum Reprod* 2012;27:3412-6.
16. Jenkins S, Olive DL, Haney AF. Endometriosis: pathogenetic implications of the anatomic distribution. *Obstet Gynecol* 1986;67:335-8.
17. Bazot M, Lafont C, Rouzier R, Roseau G, Thomassin-Naggara I, Daraï E. Diagnostic accuracy of physical examination, transvaginal sonography, rectal endoscopic sonography, and magnetic resonance imaging to diagnose deep infiltrating endometriosis. *Fertil Steril* 2009;92:1825-33.
18. Chapron C, Dubuisson JB, Pansini V, Vieira M, Fauconnier A, Barakat H, et al. Routine clinical examination is not sufficient for diagnosing and locating deeply infiltrating endometriosis. *J Am Assoc Gynecol Laparosc* 2002;9:115-9.

19. Moore J, Copley S, Morris J, Lindsell D, Golding S, Kennedy S. A systematic review of the accuracy of ultrasound in the diagnosis of endometriosis. *Ultrasound Obstet Gynecol* 2002;20:630-4.
20. Goncalves MO, Dias JA Jr, Podgaec S, Averbach M, Abrão MS. Transvaginal ultrasound for diagnosis of deeply infiltrating endometriosis. *Int J Gynaecol Obstet* 2009;104:156-60.
21. Hudelist G, English J, Thomas AE, Tinelli A, Singer CF, Keckstein J. Diagnostic accuracy of transvaginal ultrasound for non-invasive diagnosis of bowel endometriosis: systematic review and meta-analysis. *Ultrasound Obstet Gynecol* 2011;37:257-63.
22. Busard MP, van der Houwen LE, Bleeker MC, Pieters van den Bos IC, Cuesta MA, van Kuijk C, et al. Deep infiltrating endometriosis of the bowel: MR imaging as a method to predict muscular invasion. *Abdom Imaging* 2012;37:549-57.
23. Farinon AM, Vadora E. Endometriosis of the colon and rectum: an indication for preoperative colonoscopy. *Endoscopy* 1980;12:136-9.
24. Halis G, Mechsner S, Ebert AD. The diagnosis and treatment of deep infiltrating endometriosis. *Dtsch Arztebl Int Online [Internet]*. 2010 [cited 2020 Jul 31];107:446-56. Available from: <https://www.aerzteblatt.de/10.3238/arztebl.2010.0446>.
25. Andres MP, Mendes RFP, Hernandez C, Araújo SEA, Podgaec S. Hormone treatment as first line therapy is safe and relieves pelvic pain in women with bowel endometriosis. *Einstein (Sao Paulo)* 2019;17:eAO4583.
26. Ferrero S, Camerini G, Venturini PL, Biscaldi E, Remorgida V. Progression of bowel endometriosis during treatment with the oral contraceptive pill. *Gynecol Surg* 2011;8:311-3.
27. Porpora MG, Pallante D, Ferro A, Crobu M, Cerenzia P, Panici PL. Intestinal endometriosis without evident pelvic foci treated with gonadotropin-releasing hormone agonist. *Eur J Obstet Gynecol Reprod Biol* 2006;125:265-6.
28. Ferrero S, Camerini G, Ragni N, Menada MV, Venturini PL, Remorgida V. Triptorelin improves intestinal symptoms among patients with colorectal endometriosis. *Int J Gynaecol Obstet* 2010;108:250-1.
29. Szubert M, Ziętara M, Suzin J. Conservative treatment of deep infiltrating endometriosis: review of existing options. *Gynecol Endocrinol* 2018;34:10-4.
30. Meuleman C, Tomassetti C, D'Hoore A, Van Cleynenbreugel B, Penninckx F, Vergote I, et al. Surgical treatment of deeply infiltrating endometriosis with colorectal involvement. *Hum Reprod Update* 2011;17:311-26.
31. Donnez J, Squifflet J, Pirard C, Jadoul P, Wyns C, Smets M. The efficacy of medical and surgical treatment of endometriosis-associated infertility and pelvic pain. *Gynecol Obstet Invest* 2002;54 Suppl 1:2-7; discussion 7-10.
32. Rausei S, Sambucci D, Spampatti S, Cassinotti E, Dionigi G, David G, et al. Laparoscopic treatment of deep infiltrating endometriosis: results of the combined laparoscopic gynecologic and colorectal surgery. *Surg Endosc* 2015;29:2904-9.
33. Duepre HJ, Senagore AJ, Delaney CP, Marcello PW, Brady KM, Falcone T. Laparoscopic resection of deep pelvic endometriosis with rectosigmoid involvement. *J Am Coll Surg* 2002;195:754-8.
34. Ruffo G, Scopelliti F, Scioscia M, Ceccaroni M, Mainardi P, Minelli L. Laparoscopic colorectal resection for deep infiltrating endometriosis: analysis of 436 cases. *Surg Endosc* 2010;24:63-7.
35. De Cicco C, Corona R, Schonman R, Mailova K, Ussia A, Koninckx P. Bowel resection for deep endometriosis: a systematic review. *BJOG* 2011;118:285-91.
36. Zanelotti A, Decherney AH. Surgery and endometriosis. *Clin Obstet Gynecol* 2017;60:477-84.
37. Crosignani PG, Vercellini P, Biffignandi F, Costantini W, Cortesi I, Imperato E. Laparoscopy versus laparotomy in conservative surgical treatment for severe endometriosis. *Fertil Steril* 1996;66:706-11.
38. Busacca M, Fedele L, Bianchi S, Candiani M, Agnoli B, Raffaelli R, et al. Surgical treatment of recurrent endometriosis: laparotomy versus laparoscopy. *Hum Reprod* 1998;13:2271-4.
39. Fayez JA, Collazo LM. Comparison between laparotomy and operative laparoscopy in the treatment of moderate and severe stages of endometriosis. *Int J Fertil* 1990;35:272-9.
40. Jones KD, Sutton C. Patient satisfaction and changes in pain scores after ablative laparoscopic surgery for stage III-IV endometriosis and endometriotic cysts. *Fertil Steril* 2003;79:1086-90.
41. Chopin N, Vieira M, Borghese B, Foulot H, Dousset B, Coste J, et al. Operative management of deeply infiltrating endometriosis: results on pelvic pain symptoms according to a surgical classification. *J Minim Invasive Gynecol* 2005;12:106-12.
42. Garry R, Clayton R, Hawe J. The effect of endometriosis and its radical laparoscopic excision on quality of life indicators. *BJOG* 2000;107:44-54.
43. Hidaka T, Nakashima A, Hashimoto Y, Saito S. Effects of laparoscopic radical surgery for deep endometriosis on endometriosis-related pelvic pain. *Minim Invasive Ther Allied Technol* 2012;21:355-61.
44. Niewegłowska D, Hajdyla-Banas I, Pitynski K, Banas T, Grabowska O, Juszczyk G, et al. Age-related trends in anti-Mullerian hormone serum level in women with unilateral and bilateral ovarian endometriomas prior to surgery. *Reprod Biol Endocrinol* 2015;13:128
45. Llarena NC, Falcone T, Flyckt RL. Fertility preservation in women with endometriosis. *Clin Med Insights Reprod Health* 2019;13:1179558119873386.
46. Wattiez A, Puga M, Albornoz J, Faller E. Surgical strategy in endometriosis. *Best Pract Res Clin Obstet Gynaecol* 2013;27:381-92.
47. Daniels J, Gray R, Hills RK, Latthe P, Buckley L,

- Gupta J, et al. Laparoscopic uterosacral nerve ablation for alleviating chronic pelvic pain: a randomized controlled trial. *JAMA* 2009;302:955-61.
48. Vercellini P, Aimi G, Busacca M, Apolone G, Uglietti A, Crosignani PG. Laparoscopic uterosacral ligament resection for dysmenorrhea associated with endometriosis: results of a randomized, controlled trial. *Fertil Steril* 2003;80:310-9.
 49. Chapron C, Dubuisson JB, Fritel X, Fernandez B, Poncelet C, Béguin S, et al. Operative management of deep endometriosis infiltrating the uterosacral ligaments. *J Am Assoc Gynecol Laparosc* 1999;6:31-7.
 50. Possover M, Diebolder H, Plaul K, Schneider A. Laparoscopically assisted vaginal resection of rectovaginal endometriosis. *Obstet Gynecol* 2000;96:304-7.
 51. Protopapas A, Giannoulis G, Chatzipapas I, Athanasiou S, Grigoriadis T, Haidopoulos D, et al. Posterior deep infiltrating endometriotic nodules: Operative considerations according to lesion size, location, and geometry, during One's learning curve. *ISRN Obstet Gynecol* 2014;2014:853902.
 52. Abuzeid MI, Ashraf M, Shamma FN. Temporary ovarian suspension at laparoscopy for prevention of adhesions. *J Am Assoc Gynecol Laparosc* 2002;9:98-102.
 53. Possover M, Quakernack J, Chiantera V. The LANN technique to reduce postoperative functional morbidity in laparoscopic radical pelvic surgery. *J Am Coll Surg* 2005;201:913-7.
 54. Redwine DB, Sharpe DR. Laparoscopic segmental resection of the sigmoid colon for endometriosis. *J Laparoendosc Surg* 1991;1:217-20.
 55. Redwine DB, Koning M, Sharpe DR. Laparoscopically assisted transvaginal segmental resection of the rectosigmoid colon for endometriosis. *Fertil Steril* 1996;65:193-7.
 56. Chapron C, Fauconnier A, Vieira M, Barakat H, Dousset B, Pansini V, et al. Anatomical distribution of deeply infiltrating endometriosis: surgical implications and proposition for a classification. *Hum Reprod* 2003;18:157-61.
 57. Landi S, Ceccaroni M, Perutelli A, Allodi C, Barbieri F, Fiaccavento A, et al. Laparoscopic nerve-sparing complete excision of deep endometriosis: is it feasible? *Hum Reprod* 2006;21:774-81.
 58. Ruffo G, Rossini R. The outcomes of laparoscopic resection of bowel endometriosis. *Curr Opin Obstet Gynecol* 2013;25:302-7.
 59. Schneider A, Touloupidis S, Papatsoris AG, Triantafyllidis A, Kollias A, Scheweppe KW. Endometriosis of the urinary tract in women of reproductive age. *Int J Urol* 2006;13:902-4.
 60. Donnez J, Spada F, Squifflet J, Nisolle M. Bladder endometriosis must be considered as bladder adenomyosis. *Fertil Steril* 2000;74:1175-81.
 61. Kovoov E, Nassif J, Miranda-Mendoza I, Wattiez A. Endometriosis of bladder: outcomes after laparoscopic surgery. *J Minim Invasive Gynecol* 2010;17:600-4.
 62. Nerli RB, Reddy M, Koura AC, Prabha V, Ravish IR, Amarkhed S. Cystoscopy-assisted laparoscopic partial cystectomy. *J Endourol* 2008;22:83-6.
 63. Walid MS, Heaton RL. Laparoscopic partial cystectomy for bladder endometriosis. *Arch Gynecol Obstet* 2009;280:131-5.
 64. Stopiglia RM, Ferreira U, Faundes DG, Petta CA. Cystoscopy-assisted laparoscopy for bladder endometriosis: modified light-to-light technique for bladder preservation. *Int Braz J Urol* 2017;43:87-94.
 65. Litta P, Saccardi C, D'Agostino G, Florio P, De Zorzi L, Bianco MD. Combined transurethral approach with Versapoint® and laparoscopic treatment in the management of bladder endometriosis: technique and 12 months follow-up. *Surg Endosc* 2012;26:2446-50.
 66. Marcoux S, Maheux R, Bérubé S. Laparoscopic surgery in infertile women with minimal or mild endometriosis. *Canadian Collaborative Group on Endometriosis. N Engl J Med* 1997;337:217-22.
 67. Jacobson TZ, Duffy JM, Barlow DH, Farquhar C, Koninckx PR, Olive D. Laparoscopic surgery for subfertility associated with endometriosis. *Cochrane Database Syst Rev* 2014;CD001398.
 68. Vercellini P, Viganò P, Frattaruolo MP, Borghi A, Somigliana E. Bowel surgery as a fertility-enhancing procedure in patients with colorectal endometriosis: methodological, pathogenic and ethical issues. *Hum Reprod* 2018;33:1205-11.
 69. Vercellini P, Barbara G, Buggio L, Frattaruolo MP, Somigliana E, Fedele L. Effect of patient selection on estimate of reproductive success after surgery for rectovaginal endometriosis: literature review. *Reprod Biomed Online* 2012;24:389-95.
 70. Iversen ML, Seyer-Hansen M, Forman A. Does surgery for deep infiltrating bowel endometriosis improve fertility? A systematic review. *Acta Obstet Gynecol Scand* 2017;96:688-93.