

# Deep endometriosis infiltrating the recto-sigmoid: critical factors to consider before management

Mauricio Simões Abrão<sup>1,\*</sup>, Felice Petraglia<sup>2</sup>, Tommaso Falcone<sup>3</sup>, Joerg Keckstein<sup>4</sup>, Yutaka Osuga<sup>5</sup>, and Charles Chapron<sup>6,7,8</sup>

<sup>1</sup>Endometriosis Division, Obstetrics and Gynecological Department – Sao Paulo University, Sao Paulo, Brazil <sup>2</sup>Obstetrics and Gynecology, Department of Molecular and Developmental Medicine, University of Siena, Siena, Italy <sup>3</sup>Obstetrics, Gynecology and Women's Health Institute, Cleveland Clinic, Cleveland, OH, USA <sup>4</sup>Department of Obstetrics and Gynecology, Center for Endometriosis, Villach Hospital, Villach, Austria <sup>5</sup>Department of Obstetrics and Gynecology, Faculty of Medicine, University of Tokyo, Hongo, Bunkyo, Tokyo, Japan <sup>6</sup>Université Paris Descartes, Sorbonne Paris Cité, Faculté de Médecine, Assistance Publique – Hôpitaux de Paris (AP- HP), Groupe Hospitalier Universitaire (GHU) Ouest, Centre Hospitalier Universitaire (CHU) Cochin, Department of Gynecology Obstetrics II and Reproductive Medicine, 75679 Paris, France <sup>7</sup>Institut Cochin, Université Paris Descartes, Sorbonne Paris Cité CNRS (UMR 8104), Paris, France <sup>8</sup>Inserm, Université Paris Descartes, Sorbonne Paris Cité, Unité de recherche U1016, Paris, France

\*Correspondence address. Rua São Sebastião, 550, 04708-001, São Paulo, SP, Brazil. Tel: +55-11-5180-3344; Fax: +55-11-5180-3351; E-mail: msabrao@mac.com

Submitted on September 29, 2014; resubmitted on December 18, 2014; accepted on January 6, 2015

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**BACKGROUND:** Deep endometriosis invading the bowel constitutes a major challenge for the gynecologist. In addition to the greater impact on pain, the high incidence of surgical morbidity involved with bowel endometriosis poses a therapeutic dilemma for the surgeon. Intestinal involvement by deep endometriotic nodules has been estimated to occur in 8–12% of women with endometriosis. Individual and clinical factors, pre-operative morphologic characteristics from imaging, surgical considerations and impact on quality of life are critical variables that should be considered in determining the best therapeutic strategy for a patient with deep endometriosis involving the sigmoid and/or the rectum. Pre-operative planning is fundamental for defining the optimal therapeutic strategy; patient counseling of treatment options, and when surgery is indicated, involvement of a multidisciplinary surgical team is required.

**METHODS:** The PubMed and Cochrane database were searched for all original and review articles published in English, French and Italian, until June 2014. Search terms included 'deep endometriosis', 'surgical and clinical approach', 'bowel disease', 'quality of life', 'management of deep endometriosis'. Special attention was paid to articles comparing features of discoid and segmental resection.

**RESULTS:** The rationale for the best therapeutic options for patients with deep endometriosis has been shown and an evidence-based treatment algorithm for determining when and which surgical intervention may be required is proposed. In deciding the best treatment option for patients with deep endometriosis involving the sigmoid and rectum, it is important to understand how the different clinical factors and pre-operative morphologic imaging affect the algorithm. Surgery is not indicated in all patients with deep endometriosis, but, when surgery is chosen, a complete resection by the most appropriate surgical team is required in order to achieve the best patient outcome.

**CONCLUSION:** In women with deep endometriosis, surgery is the therapy of choice for symptomatic patients when deep lesions do not improve with a medical treatment.

**Key words:** deep endometriosis / ultrasound / MRI / minimally invasive surgery / recurrence

## Introduction

Deep endometriosis (DE) invading the bowel constitutes a major challenge for the gynecologist. In addition to the greater impact on pain (Fauconnier and Chapron, 2005; Jacobson et al., 2009), the high incidence of surgical morbidity involved with bowel (Vercellini et al., 2009a; Roman et al., 2011; Ruffo et al., 2012) poses a therapeutic dilemma for the surgeon (Chapron et al., 2004; Abrão et al., 2007). Intestinal involvement by deep endometriotic nodules has been estimated to occur in 8–12% of women with endometriosis (Seracchioli et al., 2007; Wills et al., 2008), and colorectal disease represents almost 90% of these cases (Coronado et al., 1990; Bailey et al., 1994; Tran et al., 1996; Jerby et al., 1999; Remorgida et al., 2007; De Cicco et al., 2011).

Deep endometriosis is defined as endometriosis involving the bowel only if the muscularis layer is affected (Chapron et al., 2010) (Fig. 1). Lesions with dense adhesions and/or endometriotic infiltration up to the bowel serosa are not considered DE, because these lesions usually are <5 mm in depth. To determine the best therapeutic options for patients with DE involving the sigmoid and/or rectum, it is important to understand the roles of clinical factors, pre-operative morphologic characteristics from imaging, surgical considerations, recurrence rate and impact on quality of life. The analysis of all these parameters may contribute to restraining the current trend toward excessive use of laparoscopic colorectal resections (Acién et al., 2013).

The present review produces an overview of the main critical factors that should be considered in determining the best therapeutic options for patients with DE and proposes an evidence-based treatment algorithm in determining when may be required and which surgical intervention should be chosen.

## Methods

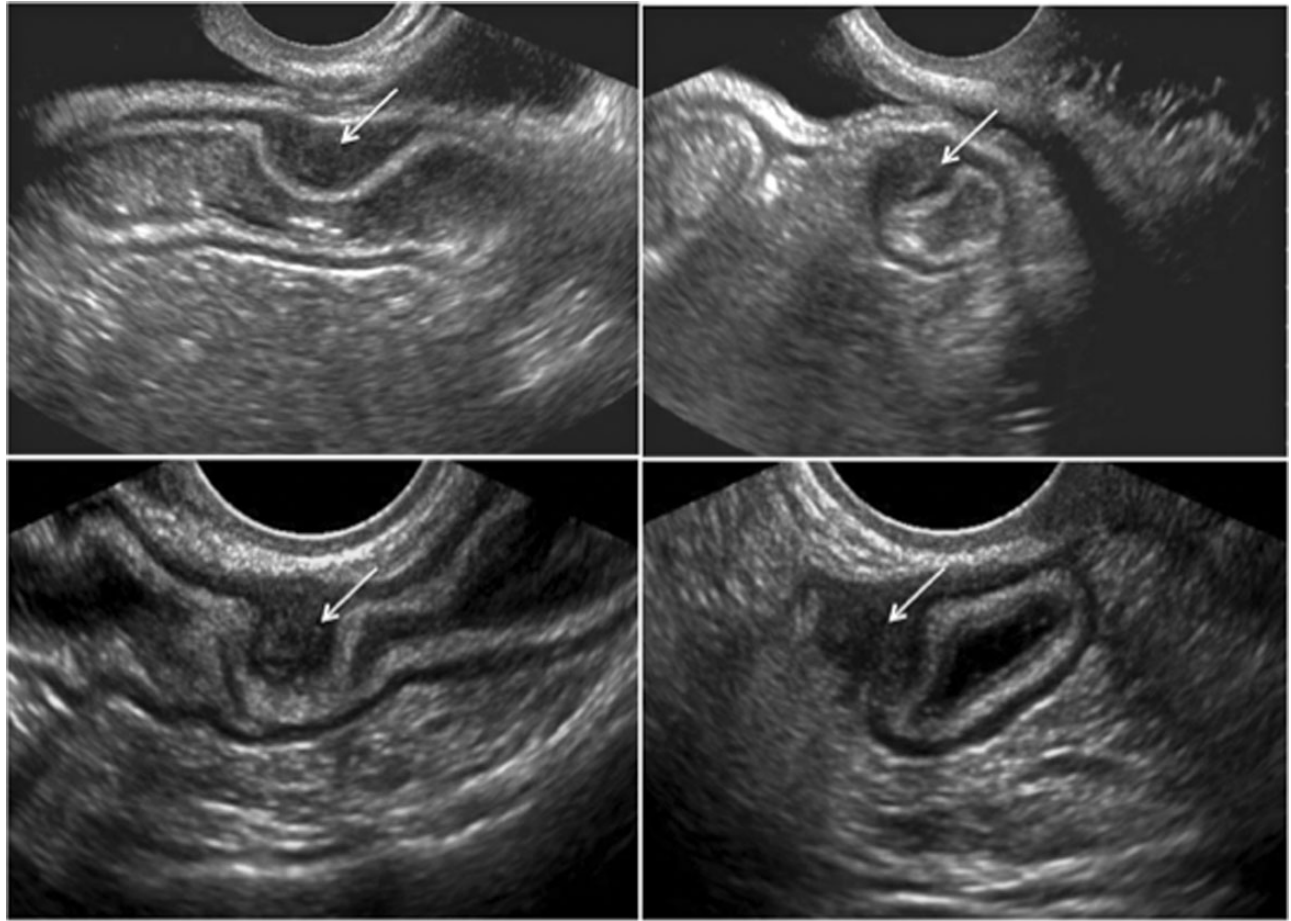
This review is based upon a literature search in PubMed and Cochrane database focusing on original and review articles published in English, French and Italian, until June 2014. Search terms included 'deep endometriosis', 'surgical and clinical approach', 'bowel disease'. Special attention was paid to articles comparing features of discoid and segmental resection. Reference lists from all relevant original articles and review articles were consulted in order to identify additional studies. This preliminary search resulted in 291 articles. To ensure the relevance of the publications retrieved, additional inclusion criteria were applied which contained an explanation of the surgical technique used as well as an adequate follow-up phase describing data on at least one of

the following terms: post-operative complications, evaluation of pain (dysmenorrhea, dyspareunia, chronic non-menstrual pelvic pain) and management of deep endometriosis. This second screening resulted in 167 citations. Additionally, the terms: quality of life (pre-operative versus post-operative), fertility and recurrence rate were also considered, resulting in 35 articles. The citations whose content did not address the specific proposed objectives in this study were excluded. Finally, a total of 122 articles were retained for analysis.

## Clinical symptoms and co-morbidities

Compared with peritoneal and ovarian endometriosis, DE is associated more frequently with dysmenorrhea, dyspareunia, noncyclic pelvic pain and infertility (Ruffo et al., 2010; Chapron et al., 2012), as well as specific bowel symptoms, including cyclic bowel alterations, dyschezia and rectal bleeding (Remorgida et al., 2007). The bowel disease affects patient quality of life as it can increase the number of evacuations or cause progressive constipation leading to bowel obstruction (Bailey et al., 1994; Garry et al., 2000; Redwine and Wright 2001; Daraï et al., 2007a; Dousset et al., 2010; Fourquet et al., 2011). A prospective study performed by Roman et al. (2012) demonstrated that women presenting with rectal endometriosis were more likely to present a high prevalence of digestive complaints, such as cyclic defecation pain and cyclic constipation, although these complaints were also frequent in women with deep endometriosis without digestive involvement. Rectal stenosis was observed in 26.4% of women with rectal endometriosis, suggesting that various digestive complaints may be unrelated to rectal infiltration by the deep endometriotic nodules. Symptoms can be similar to irritable bowel syndrome and may even mimic colonic adenocarcinoma (Haggag et al., 2011). The degree of symptoms may not be correspondent to the size of the lesions and painful symptoms are not indicative of surgical intervention. Some patients with extensive rectosigmoid endometriosis can be almost asymptomatic (Chapron et al., 2010), while others with small lesions can present severe symptoms. This makes it more difficult to indicate an intervention, especially with radical surgery (Daraï et al., 2007b).

In several patients, the presence of deep endometriosis coincides with other forms of endometriosis. When only rectosigmoid lesions patients were evaluated, 48 and 84% had ovarian endometriosis and retrocervical lesions, respectively (Goncalves et al., 2010). These findings are relevant



**Figure 1** Transvaginal ultrasound showing a hypoechoic lesion suggesting endometriosis compromising the muscularis layer of the rectum.

considering the other possible sites whenever the disease is present in the bowel (Chapron *et al.*, 2003). Both superficial peritoneal and ovarian endometrioma may be found in association with DE in variable percentages, thus contributing to the intensity of painful stimuli as well as to the infertility status (Chapron *et al.*, 2012), and also contributing to the question of whether DE is an independent form of the disease or represents the most severe clinical representation (Acién and Velasco, 2013). Indeed, some cases of DE are described at a second surgery for endometriosis, and the history of a previous surgery is a marker for severity of the disease (Sibiude *et al.*, 2014). In a series of recent studies, it has been shown that DE is associated in >70% of cases with adenomyosis (Lazzeri *et al.* 2014), raising the question of common pathogenic mechanisms underlying such pathologies (Ferreiro *et al.*, 2009a, b; Di Donato and Seracchioli, 2014). Other concurrent chronic inflammatory diseases have also been found in association with DE, such as inflammatory bowel disease (Jess *et al.*, 2012).

The relationship between DE and infertility is controversial (van Dijk *et al.*, 2011). There are no studies showing that bowel endometriosis causes more infertility than other locations of the disease, and in most cases of bowel disease, the other sites are also compromised (Somigliana *et al.*, 2007; Chapron *et al.*, 2009). So it is difficult to determine the specific contribution of each affected sites. Individual (age, hormonal status, desire for fertility) and clinical factors (intensity of pain, pre-operative

findings) should be considered in the treatment algorithm of patients with DE. Surgery should be indicated only in the following situations: (i) patients who present with significant pain such as dyspareunia and dyschezia (VAS > 7) (Anaf *et al.*, 2000; Chapron *et al.*, 2012) that results in major impairment of quality of life; (ii) patients who present with signs of bowel obstruction; and (iii) patients who have failed previous *in vitro* fertilization (IVF) cycles (Littman *et al.*, 2005). Symptomatic patients approaching menopause may be treated more conservatively, in comparison to younger patients with advanced disease and severe symptoms.

Asymptomatic patients whose lesions were diagnosed on clinical exam and/or radiologic findings do not systematically warrant surgery. However, a large lesion that compromises the lumen of the recto-sigmoid, a severe hemorrhage, or a progressive disease, can be an indication for surgery (Bachmann *et al.*, 2014).

The best treatment approach for infertile patients with asymptomatic bowel lesion is still controversial. There is only one prospective study showing that surgery improved IVF for patients with bowel endometriosis. This study was limited however by its lack of proper randomization (Bianchi *et al.*, 2009). Only after two IVF failures should bowel surgery be considered due to the lack of Level I evidence that surgery may improve pregnancy rates. In cases of infertility associated with pain, both options of surgery and ART have been shown to result in a satisfactory chance of

pregnancy (De Ziegler et al., 2010). When surgery is indicated, there are two options concerning the surgical modalities. Firstly, the pregnancy rate after minimally invasive procedures (shaving and discoid excision) seemed to be higher in a preliminary study, when compared with segmental resection (Mohr et al., 2005). Secondly, some studies have demonstrated high pregnancy rates after laparoscopic bowel resection, for symptomatic women: from 41.6 to 45.5% of women wishing to conceive after surgery (Darai et al., 2008; Ferrero et al., 2009a, b; Minelli et al., 2009; Meuleman et al., 2014). If the pain is not severe and the desire for pregnancy is the priority, proceeding to ART is the best approach. On the other hand, in cases with debilitating pain, in patients with moderate (stage III) or severe (stage IV) endometriosis (intestinal and/or other sites of disease), surgery is indicated first and ART is proposed when no pregnancy occurs, resulting in a delay of >6 months (Pagidas et al., 1996).

In a prospective, multicenter study performed by Ballester et al. (2012), ICSI-IVF offered a high cumulative pregnancy (CPR) rate in patients without prior surgery for deep infiltrating endometriosis. A progressive increase in the CPR was observed after one, two and three ICSI-IVF cycles/patient, 29.3, 52.9 and 68.6%, respectively. However, determinant factors of the CPR should be considered, such as the presence of adenomyosis, anti-Mullerian hormone levels and the patient age. In patients with colorectal endometriosis, the presence of adenomyosis appears to be a negative determinant factor of fertility outcome in ICSI-IVF.

A review evaluating the effect of conservative surgery for rectovaginal and rectosigmoid endometriosis on reproductive performance demonstrated that the mean pregnancy rate after surgery in all patients who wanted to become pregnant, independently of pre-operative fertility status and IVF performance, was 39%, but in patients who conceived spontaneously, the pregnancy rate was only 24% (Vercellini et al., 2012).

When the patient's priority is to conceive, there is no clear consensus (first surgery or first ICSI-IVF), which determines the fertility outcome. Within this same reasoning, the results of Cohen et al. (2014) suggested a potential benefit of combining surgery and medically assisted reproduction (*in vitro* fertilization and intrauterine insemination) on fertility outcomes in patients with bowel endometriosis, whereas in patients with DE without bowel involvement, a high spontaneous pregnancy rate was reported.

Recently, in preliminary results related to women with colorectal endometriosis, the overall pregnancy rate after primary surgery, followed or not by IVF, reached up to 66% (ENDORE – VCE Sao Paolo, 2014).

For asymptomatic patients and when the pelvic pain is not a deleterious symptom to the patient, assisted reproductive technology must be the first-line option for the treatment of infertility.

## Modalities for pre-operative diagnosis of deep endometriosis

Deep endometriotic nodules involving the retrocervical region, uterosacral ligaments, vagina and recto-sigmoid must be accurately detected pre-operatively, so, the adequate use of complementary diagnostic methods is very important. The use of the ENZIAN-score (Tuttlies et al., 2005) can also be helpful for planning the surgical procedure.

In multiple published studies, transvaginal ultrasound (TVUS) with bowel preparation has shown a superior sensitivity (75–98%) for

detecting DE compared with magnetic resonance imaging, transrectal ultrasonography, computer tomography and clinical examination (Abrao et al., 2007; Pronio et al., 2007). When endometriosis involves the recto-sigmoid, TVUS with bowel preparation is able to define not only the size and number of lesions, but also the depth of invasion into the bowel wall and the distance from the anal verge (Guerrero et al., 2008; Hudelist et al., 2009; Goncalves et al., 2010). For these patients, pre-operative TVUS must be the first-line imaging modality (Piketty et al., 2009; Goncalves et al., 2010). Recently, a well-defined protocol for performing an accurate TVUS evaluation in cases of DE has been proposed and may represent a valid pre-surgical approach (Exacoustos et al., 2014). Some authors recommend that the pre-operative work-up should also include a colonoscopy and magnetic resonance imaging (MRI) (Zanardi et al., 2003). Meuleman et al. (2011) described that, in 59% of the studies analyzed, the pre-operative assessment of bowel endometriosis included barium enema (26%), computerized tomography (31%) and/or MRI (28%). After diagnosis, pre-operative planning along with patient counseling is fundamental for defining the optimal therapeutic strategy and, when surgery is indicated, involvement of a multidisciplinary surgical team is required.

## Anatomical and histological characteristics

According to the Sampson's theory concerning endometriosis pathogenesis (Sampson, 1927), endometriotic lesions affect the recto-sigmoid starting from the serosa, invade towards the lumen of the bowel and finally infiltrate the rectal wall. The fibrotic component represents around 80% of the lesions in cases of intestinal endometriosis and therefore, surgical management is more difficult (Thomassin et al., 2004). In this context, it is important to evaluate the surgical treatment carefully, considering the risk of complications associated with these complex procedures (Abrao et al., 2006; Benbara et al., 2008). With this understanding, it is important to precisely define the parameters that are crucial to determine the best surgical approach. These parameters are described below.

### Number of intestinal DE lesions

Multifocality is one of the main characteristics of DE, especially when the intestinal tract is involved (Chapron et al., 2003). When deep endometriosis affects the recto-sigmoid, multifocal bowel lesions are observed in 40% or more patients (Remorgida et al., 2005; Chapron et al., 2006). Kavallaris et al. (2003) reported that for rectal endometriosis, multifocal involvement (defined as presence of deep lesions within 2 cm area of the main lesions) and multicentric involvement (defined as a satellite deep nodule found >2 cm from the main lesions) were observed respectively in 62 and 38% of the cases. These histopathological observations were in accordance with the observations of Anaf et al. (2004) who demonstrated that deep endometriotic lesions infiltrate the large bowel wall preferentially along the nerves, even at a distance from the palpated nodule, while the mucosa is rarely and only focally involved.

### Size of the intestinal DE lesion(s)

Lesions larger than 3 cm in diameter require a segmental resection in order to avoid significant distortion of the bowel axis and subsequent stricture (Abrao et al., 2008; Moawad et al., 2011). Alternatively, an



original technique using combined laparoscopic and transanal approaches, including deep rectal shaving, followed by transanal full-thickness disc excision was performed in a 30-year-old nullipara. Rectal stenosis was due to a large endometriotic nodule infiltration measured over 30 mm in diameter. The authors support that this conservative technique is feasible in large low rectal endometriosis and can prevent complications inherent to low colorectal resection (Roman *et al.*, 2014; Roman and Tuech, 2014a, b). Fibrotic tissue must be considered part of the lesions, as evidence suggests that estrogen and progesterone receptors are present not only in glands and stroma but also in the smooth muscle and fibrosis surrounding the lesions of bowel endometriosis (Noël *et al.*, 2010). We recommend complete excision of the surrounding fibrotic tissue during surgery in order to prevent disease recurrence. A discoid resection could be considered only for nodules smaller than 3 cm (Remorgida *et al.*, 2005; de Almeida *et al.*, 2014).

### Extent of bowel circumference involvement

The extent of the bowel circumference compromised is positively correlated with the depth of the endometriotic nodule invasion into the bowel wall (Abrao *et al.*, 2008). In this study, it was demonstrated that when the DE involves the rectum and/or sigmoid deeper than the submucosal layer, the circumference of the bowel affected by the disease is higher than 40% (Abrao *et al.*, 2003). For these situations, removing a disk that compromises >40% of the circumference of the rectum could put the patient at risk for bowel stenosis.

### Depth of lesions

It is also important to consider how deeply the bowel wall is infiltrated by endometriotic lesions. The lesions of the serosa without infiltration of the muscularis are superficial, and may not justify any specific surgical bowel procedure (Chapron *et al.*, 2003). In a literature review, Meuleman *et al.* (2011) reported that 95% of the patients undergoing bowel resection anastomosis had bowel serosa involvement; 95% had lesions infiltrating the muscularis while 38% had lesions infiltrating the submucosa and 6% had lesions infiltrating the mucosa.

### Distance to the anal verge

The distance of the inferior border of the lowest bowel lesion to the anal verge should be evaluated pre-operatively. The surgical treatment of low rectal lesions (defined as <5–8 cm from the anal verge) is associated with a higher risk of post-operative anastomotic leaks (Ruffo *et al.*, 2010) and transient neurogenic bladder dysfunction (Dousset *et al.*, 2010). However an innovative technique combining a laparoscopic and transanal approach can be applied to remove the full thickness of the infiltrating endometrial nodules of the lower and middle rectum. This technique avoids post-operative complaints, especially rectal stenosis and denervation and its related symptoms (Bridoux *et al.*, 2012; Roman and Tuech, 2014b). It is therefore critical to obtain this information prior to surgery (Pronio *et al.*, 2007; Goncalves *et al.*, 2010).

### Histological pattern classification

Histologic patterns associated with endometriosis may be well-differentiated glandular, pure stromal, glandular or mixed differentiation, or pure undifferentiated glandular (Abrao *et al.*, 2003). Deep infiltrative lesions are significantly associated with the undifferentiated glandular pattern (Abrao *et al.*, 2003; Kamergorodsky *et al.*, 2009) and with

disease stages III and IV (Abrao *et al.*, 2003). This finding suggests that undifferentiated endometriotic lesions (when the epithelium is flattened or low cuboidal, with no correspondence with eutopic endometrium) possibly the result from the tissue's inability to respond to suppressor effects of the peritoneal fluid, allowing these endometrial foci to infiltrate more deeply (Kamergorodsky *et al.*, 2009).

### Lymphatic dissemination

After segmental bowel resection for deep endometriosis, lymph node involvement is observed between 26 and 42% of the cases and is correlated with the severity of the disease (Abrao *et al.*, 2006; Noël *et al.*, 2008; Mechsner *et al.*, 2010). Lymph node involvement is correlated with the size of the bowel lesion (Abrao *et al.*, 2006; Noël *et al.*, 2008; Mechsner *et al.*, 2010), the percentage of the intestinal wall affected by the deep nodule (Abrao *et al.*, 2006) and the presence of lymphovascular invasion which can contribute to post-operative recurrence (Noël *et al.*, 2008).

### Parameters to be considered for surgery

The size of the lesions, depth of infiltration, percentage of the intestinal wall circumference infiltrated and lymph node involvement are all correlated and are not independent parameters. Because of these findings, complete resection of large size nodules with lymphovascular involvement is important in order to avoid residual disease. The rate of recurrence has been correlated with the completeness of surgical excision (Sibiude *et al.*, 2014). Similar conclusions were obtained by Nirgianakis *et al.* (2014), when clinical and histological characteristics were examined as possible predictive factors for bowel endometriosis recurrence after laparoscopic segmental bowel resection. Three independent predictor factors, positive bowel resection margins, age <31 years and body mass index  $\geq 23$  kg/m<sup>2</sup>, were also significantly associated with recurrence which was observed in 16% of patients. Additionally as the surgeon's skills increase, the surgery becomes more complete and the recurrence rate significantly decreases (Carmona *et al.*, 2009).

To summarize, the complete exeresis of bowel endometriotic lesions could be most effective for avoiding recurrence of the disease, but this depends upon the parameters described above: the number, size and depth of intestinal nodules, associated fibrosis, rectal circumference involvement, lymph node involvement and distance to the anal verge.

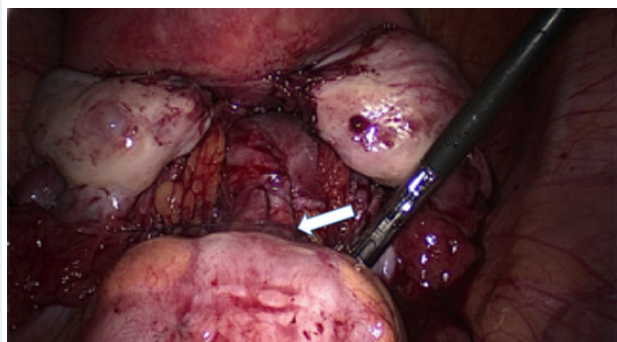
## Surgery, complications and recurrences

The complete excision of all endometriotic lesions is the main objective of both laparoscopic and laparotomic surgeries which require a multidisciplinary approach (Possover *et al.*, 2000; Keckstein and Wiesinger, 2005) and highly skilled surgeons.

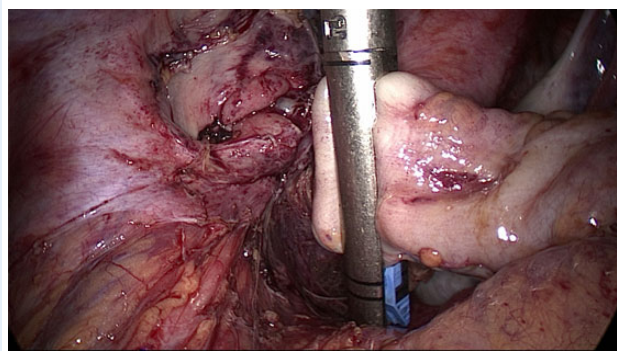
Laparoscopic excision of deep infiltrating bowel endometriosis has become a frequently used treatment modality, and segmental bowel resection has been performed in many cases, despite the relatively high rate of morbidity. However, in most of the studies (Ford *et al.*, 2004; Campagnacci *et al.*, 2005; Mohr *et al.*, 2005; Brouwer and Woods, 2007; Pereira *et al.*, 2009), the indication of segmental resection instead of more conservative surgery methods is often not documented, and there are few studies comparing the results of different surgical techniques. Three studies have provided results related to the comparison of different surgical approaches (nodule excision, shaving and segmental

resection) for the management of women presenting colorectal endometriosis and its impact on digestive symptoms (Roman et al., 2010, 2011, 2013). Most of the authors also do not compare the quality of life for women after radical surgery with others who have not undergone bowel resection. In these conditions, it is difficult to determine whether a greater or similar health improvement can be achieved with less aggressive surgery (Acien et al., 2013). However according to Roman et al. (2013), post-operative digestive symptoms may be associated with different surgical philosophies regarding radical and conservative approaches (colorectal resection and shaving/rectal nodule excision, respectively). For women managed for rectal endometriosis, better functional outcomes were observed in those who underwent conservative surgical approaches aiming at rectal conservation instead of routine radical rectal excision.

The three options in the surgical treatment of endometriosis of the rectosigmoid include: (i) the shaving technique (Donnez and Squifflet, 2010; Mabrouk et al., 2011; Roman et al., 2011; Moawad and Caplin, 2013); (ii) resection of the endometriotic nodule (nodular resection) (Reich, 1997; Fanfani et al., 2010; Oliveira et al., 2014); and (iii) segmental resection with end-to-end anastomosis (Panebianco et al., 1994; Duepre et al., 2002; Abrão et al., 2008; Dousset et al., 2010; Roman et al., 2011). Figures 2 and 3 represent nodular and segmental bowel resection of endometriotic lesions respectively.



**Figure 2** Endometriosis lesion with <3 cm of longitudinal diameter being resected with a circular stapler (disc resection).



**Figure 3** Segmental resection of the rectum for a multifocal endometriosis.

For advanced endometriosis with bowel extension, different nerve sparing techniques used in surgeries for pelvic malignant disease are successful in reducing functional problems (urine retention, constipation, sexual dysfunction) related to pelvic denervation after surgery (Maas et al., 1999; Possover et al., 2005; Landi et al., 2006).

Both major and minor surgical complications have been reported after surgical excision of deep endometriosis involving the bowel. These include: fistula (0–14%) (Duepre et al., 2002; Keckstein and Wiesinger, 2005; Ruffo et al., 2010), hemorrhage (1–11%) (Darai et al., 2007a; Seracchioli et al., 2007), infections (1–3%) (Meuleman et al., 2009; Ruffo et al., 2010), laparoconversion (up to 12%) (Dubernard et al., 2006; Darai et al., 2007a), and bladder (1–71%) and bowel (1–15%) dysfunction (Mangler et al., 2008; Ruffo et al., 2010) such as post-operative severe constipation (Armengol-Debeir et al., 2011). Considering the major complications, there are three frequently observed risk factors: opening of the vagina at the time of the bowel surgical procedure (Meuleman et al., 2011); excessive use of electrocoagulation that may increase the risk of rectovaginal fistulae and abscesses, as it can lead to necrosis of the posterior vaginal cuff (Dubernard et al., 2006); and surgical treatment of low rectal lesions (<5–8 cm from the anal verge) which increases the risk of anastomotic leaks (Ruffo et al., 2010; Trencheva et al., 2013).

It is difficult to interpret the relevance of the complications because the morphologic aspects of the disease, such as the location, size and diameter of nodule(s), are not always specifically reported (De Cicco et al., 2011). Nonetheless, it is important to note that the overall quality of life of patients with bowel endometriosis submitted to bowel surgery is significantly improved (Dousset et al., 2010; Bassi et al., 2011; Moawad et al., 2011).

Brouwer and Woods (2007) described in their review that the type of surgical approach does not change the rate of complications. However many factors are affected by the surgeon's learning curve, such as the rate of conversion, operating time, complication rate and surgical effectiveness (Carmona et al., 2009). Despite this, complications can occur even among experienced surgeons (Haggag et al., 2011).

Data regarding recurrence rates after surgical treatment of DE are scarce, since most studies available have analyzed recurrence of ovarian endometriomas (Fedele et al., 2004; Li et al., 2005; Vercellini et al., 2006). According to Meuleman et al. (2011), when considering a follow-up period >2 years, in general, the recurrence rate after surgery observed in several studies varied between 4 and 25%. When comparing bowel resection anastomosis groups and mixed study groups (full-thickness disc excision, bowel resection anastomosis, shave/superficial excision), the recurrence rates were 5.8 and 17.6%, respectively.

In a recent review, the surgical treatment of DE provides excellent results, with >85% of women showing complete improvement of symptoms and recurrence rates lower than 5% (Koninckx et al., 2012). Recurrence of deep endometriosis can be invariably considered a result of incomplete surgery (Vignali et al., 2005; Koninckx et al., 2012). The indication of a second surgery must be based on a meticulous evaluation of risks and benefits, since it has been demonstrated that repeat conservative surgery for DE has the same efficacy and limitations as primary surgery (Vercellini et al., 2009a; Berlanda et al., 2010). When a second surgical approach is intended, definitive surgery (hysterectomy and bilateral oophorectomy) promotes the best results and must be considered, particularly in women over 40 years old and who do not

wish to conceive (Vercellini *et al.*, 2009b). Alternatively, it has been shown that hormonal and non-hormonal medical treatments may provide a good efficacy for the treatment of pain in women presenting recurrent DE (Razzi *et al.*, 2007; Rocha *et al.*, 2012; Borghese *et al.*, 2014). When dealing with recurrence of DE, it is important to distinguish between pain control and fertility as the main goal of treatment. For patients in whom fertility is the aim, there is clear evidence that assisted reproductive technology leads to better results compared with a second operation (The Practice Committee of the ASRM, 2006; Vercellini *et al.*, 2009c; Berlanda *et al.*, 2013).

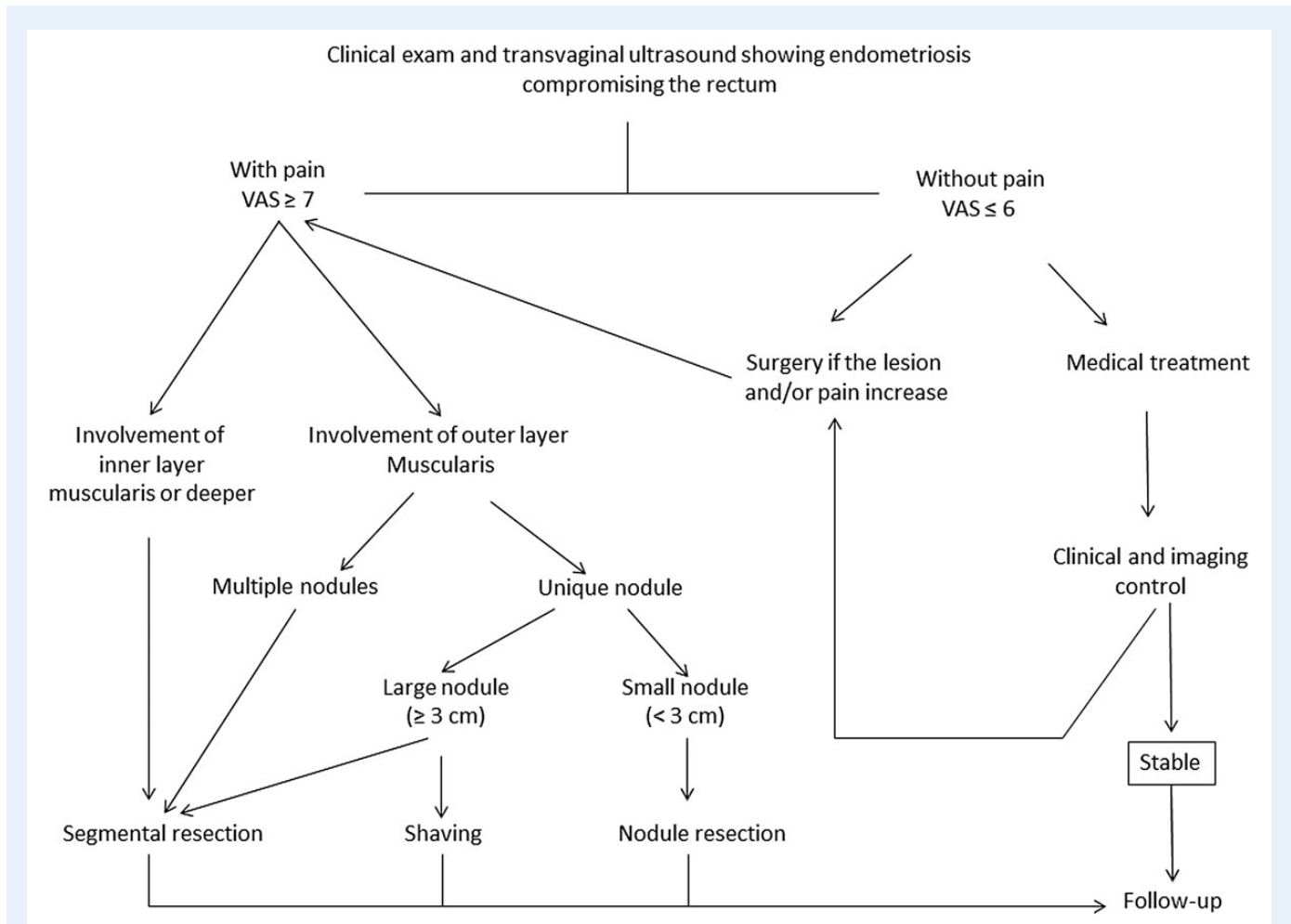
## The modern management of bowel endometriosis and quality of life

The treatment algorithm for deep endometriosis compromising the bowel must be individualized (Fig. 4). Critical clinical factors such as the age of the patient, intensity of pain (VAS > 7), risk of bowel obstruction and desire for pregnancy should be considered. Asymptomatic patients with deep intestinal nodule do not require surgery and must be followed clinically (for pain symptoms) and perhaps sonographically

(for enlargement of lesion that may compromise bowel lumen) (Abrao *et al.*, 2007; Hudelist *et al.*, 2009; Goncalves *et al.*, 2010).

For asymptomatic patients, the indications for surgery are limited to the risk of bowel obstruction and, possibly, the aim for fertility after IVF failures. For patients who are not interested in pregnancy, medical treatment should be the first option (Vercellini *et al.*, 2010). Surgery is then indicated when patients with pelvic pain do not respond to medical treatment. When surgery is chosen, complete resection of endometriosis should be performed in order to reduce the risk of residual disease (Carmona *et al.*, 2009; Sibiude *et al.*, 2014). Bowel resection with end-to-end anastomosis is preferred to nodule resections in cases of multiple intestinal nodules (to avoid multiple risky sites for dehiscence in the bowel), nodules located in the sigmoid, lesions >3 cm in size, and deep intestinal lesions involving the submucosa and/or mucosa.

Oxidized regenerated cellulose can be considered after laparoscopic surgery for endometriosis in the prevention of adhesions (Ahmad *et al.*, 2008). In a similar context, the safety and effectiveness of Seprafilm adhesion barrier, in relation to abdominal or pelvic abscess and pulmonary embolism, when administered to patients undergoing abdominopelvic surgery has been confirmed. However, when Seprafilm was used for fresh bowel anastomosis, anastomotic leaks, fistula, peritonitis, abscess or sepsis, occurred more frequently in a subpopulation of patients (Beck *et al.*, 2003).



**Figure 4** Treatment algorithm for deep endometriosis compromising the bowel. VAS: visual analogic scale.

Imaging technology and adequate training in techniques have made it possible to identify the precise characteristics of deep endometriotic nodules pre-operatively (Chapron et al., 1998; Abrao et al., 2007). The detailed imaging findings allow us to define and plan the optimal procedure prior to surgery. This permits proper patient counseling and selection of an appropriate multidisciplinary surgical team to achieve the best patient outcome (De Ziegler et al., 2011).

Although there are no specific data focused on DE post-operative management, post-operative prescription of hormonal treatment after cystectomy for endometrioma is effective for secondary prevention of recurrence (Vercellini et al., 2010) and pelvic pain (Seracchioli et al., 2009). Furthermore, recurrence of disease must be differentiated from persistence that results from incomplete excision (Sibiude et al., 2014). When a sizable deep nodule that compromises a large circumference of the bowel is detected pre-operatively, the patient should be counseled regarding the greater risk of persistence of residual disease when complete excision is not accomplished.

Intestinal endometriosis significantly impacts the quality of life (QoL) of the patients due to its association with chronic pelvic pain, dysmenorrhea, deep dyspareunia and cyclic bowel alterations (Garry et al., 2000; Redwine and Wright, 2001; Dubernard et al., 2006, 2008). The main objective of any treatment for intestinal endometriosis is to offer the best possible relief from these symptoms, thus improving the quality of life of these women. Medical treatment is only suppressive and does not cure the deep endometriosis probably because of the fibrotic component which represents around 80% of the lesions in cases of intestinal endometriosis (Thomassin et al., 2004; Darai et al., 2005). This reinforces the importance of the indication of surgical treatment (Benbara et al., 2008; English et al., 2014; Laas et al., 2014). However, medical treatment is effective for symptom relief (Ferrero et al., 2010) in numerous patients who consequently do not need surgery.

Bassi et al. (2011) used the SF-36 to evaluate the QoL of patients with bowel disease submitted to a segmental resection of the rectum. A significant increase was found after surgery in the mean scores for all the domains in this questionnaire as well as total scores, confirming the beneficial role of this surgical treatment in relieving the symptoms of rectosigmoid endometriosis and consequently in improving the QoL of these patients.

Preliminary results of an evaluation of post-operative gastrointestinal symptoms related to radical and conservative surgery for rectal endometriosis have also been reported by Roman et al. (2013). Significant improvement in QoL was achieved for women who underwent conservative surgical approach, based on the results obtained from gastrointestinal standardized questionnaires (Knowles-Eccersley-Scott Symptom Questionnaire, Gastrointestinal Quality of Life Index, and depression/self-perception Fecal Incontinence Quality of Life Score).

## Conclusions

In deciding the best treatment option for patients with deep endometriosis involving the sigmoid and rectum, it is important to understand how different clinical and pre-operative morphologic factors from clinical assessment and imaging affects the algorithm. Although surgery is not indicated in all patients with deep endometriosis, when surgery is chosen, a complete resection of the endometriosis by the most appropriate surgical team should be provided with the goal to achieve the best patient outcome.

## Acknowledgements

The authors thank Dr Marta Bellodi Privato, PhD, Luiza da Gama Coelho Riccio, MD and Igor Leonardo Padovesi Mota, MD for their assistance in writing the final version of the manuscript.

## Authors' roles

M.S.A. and C.C. developed the original design and wrote the first draft of the manuscript; M.S.A., C.C., F.P., T.F., J.K., Y.O. revised critically the manuscript for important intellectual content. All authors contributed to the writing of the final manuscript and approved it to be published.

## Funding

There are no funding sources supporting this study.

## Conflict of interest

The authors certify that they have no conflicts of interest.

## References

- Abrao MS, Neme RM, Carvalho FM, Aldrighi JM, Pinotti JA. Histological classification of endometriosis as a predictor of response to treatment. *Int J Gynaecol Obstet* 2003; **82**:31–40.
- Abrao MS, Podgaec S, Dias JA Jr, Averbach M, Garry R, Ferraz Silva LF, Carvalho FM. Deeply infiltrating endometriosis affecting the rectum and lymph nodes. *Fertil Steril* 2006; **86**:543–547.
- Abrao MS, Gonçalves MO, Dias JA Jr, Podgaec S, Chamie LP, Blasbalg R. Comparison between clinical examination, transvaginal sonography and magnetic resonance imaging for the diagnosis of deep endometriosis. *Hum Reprod* 2007; **22**:3092–3097.
- Abrao MS, Podgaec S, Dias JA Jr, Averbach M, Silva LF, Marino de Carvalho F. Endometriosis lesions that compromise the rectum deeper than the inner muscularis layer have more than 40% of the circumference of the rectum affected by the disease. *J Minim Invasive Gynecol* 2008; **15**:280–285.
- Ación P, Velasco I. Endometriosis: a disease that remains enigmatic. *ISRN Obstet Gynecol* 2013; **17**:2013:242149.
- Ación P, Núñez C, Quereda F, Velasco I, Valiente M, Vidal V. Is a bowel resection necessary for deep endometriosis with rectovaginal or colorectal involvement? *Int J Womens Health* 2013; **5**:449–455.
- Ahmad G, Duffy JMN, Farquhar C, Vail A, Vanderkerchse P, Watson A, Wiseman D. Barrier agents for adhesion prevention after gynaecological surgery. *Cochrane Database Syst Rev* 2008; Issue 2. Art. No.:CD 000475.
- Anaf V, Simon P, El Nakadi I, Fayt I, Buxant F, Simonart T, Peny MO, Noel JC. Relationship between endometriotic foci and nerves in rectovaginal endometriotic nodules. *Hum Reprod* 2000; **15**:1744–1750.
- Anaf V, El Nakadi I, Simon P, Van de Stadt J, Fayt I, Simonart T, Noel JC. Preferential infiltration of large bowel endometriosis along the nerves of the colon. *Hum Reprod* 2004; **19**:996–1002.
- Armengol-Debeir L, Savoye G, Leroi AM, Gourcerol G, Savoye-Collet C, Tuech JJ, Vassilief M, Roman H. Pathophysiological approach to bowel dysfunction after segmental colorectal resection for deep endometriosis infiltrating the rectum: a preliminary study. *Hum Reprod* 2011; **26**:2330–2335.
- Bachmann R, Bachmann C, Lange J, Krämer B, Brucker SY, Wallwiener D, Königsrainer A, Zdichavsky M. Surgical outcome of deep infiltrating colorectal endometriosis in a multidisciplinary setting. *Arch Gynecol Obstet* 2014; **290**:919–924.
- Bailey HR, Ott MT, Hartendorp P. Aggressive surgical management for advanced colorectal endometriosis. *Dis Colon Rectum* 1994; **37**:747–753.
- Ballester M, d'Argent EM, Morcel K, Belaisch-Allart J, Nisolle M, Darai E. Cumulative pregnancy rate after ICSI-IVF in patients with colorectal endometriosis: results of a multicentre study. *Hum Reprod* 2012; **27**:1043–1049.
- Bassi MA, Podgaec S, Dias JA Jr, D'Amico Filho N, Petta CA, Abrao MS. Quality of life after segmental resection of the rectosigmoid by laparoscopy in patients with deep



- infiltrating endometriosis with bowel involvement. *J Minim Invasive Gynecol* 2011; **18**:730–733.
- Beck DE, Cohen Z, Fleshman JW, Kaufman HS, van Goor H, Wolff BG; Adhesion Study Group Steering Committee. A prospective, randomized, multicenter, controlled study of the safety of Seprafilm adhesion barrier in abdominopelvic surgery of the intestine. *Dis Colon Rectum* 2003; **46**:1310–1309.
- Benbara A, Fortin A, Martin B, Palazzo L, Le Tohic A, Madelenat P, Yazbeck C. Surgical and functional results of rectosigmoidal resection for severe endometriosis. *Gynecol Obstet Fertil* 2008; **36**:1191–1201.
- Berlanda N, Vercellini P, Fedele L. The outcomes of repeat surgery for recurrent symptomatic endometriosis. *Curr Opin Obstet Gynecol* 2010; **22**:320–325.
- Berlanda N, Vercellini P, Somigliana E, Frattaruolo MP, Buggio L, Gattei U. Role of surgery in endometriosis-associated subfertility. *Semin Reprod Med* 2013; **31**:133–143.
- Bianchi PH, Pereira RM, Zanatta A, Alegretti JR, Motta EL, Serafini PC. Extensive excision of deep infiltrative endometriosis before *in vitro* fertilization significantly improves pregnancy rates. *J Minim Invasive Gynecol* 2009; **16**:174–180.
- Borghese B, Santulli P, Streuli I, Lafay-Pillet MC, de Ziegler D, Chapron C. Recurrence of pain after surgery for deeply infiltrating endometriosis: how does it happen? How to manage? *J Gynecol Obstet Biol Reprod (Paris)* 2014; **43**:12–18.
- Bridoux V, Roman H, Kianifard B, Vassilief M, Marpeau L, Michot F, Tuech JJ. Combined transanal and laparoscopic approach for the treatment of deep endometriosis infiltrating the rectum. *Hum Reprod* 2012; **27**:418–426.
- Brouwer R, Woods RJ. Rectal endometriosis: results of radical excision and review of published work. *ANZ J Surg* 2007; **77**:562–571.
- Campagnacci R, Perretta S, Guerrieri M, Paganini AM, De Sanctis A, Ciavattini A, Lezoche E. Laparoscopic colorectal resection for endometriosis. *Surg Endosc* 2005; **19**:662–664.
- Carmona F, Martínez-Zamora A, González X, Ginés A, Buñesch L, Balasch J. Does the learning curve of conservative laparoscopic surgery in women with rectovaginal endometriosis impair the recurrence rate? *Fertil Steril* 2009; **92**:868–875.
- Chapron C, Dumontier I, Dousset B, Fritel X, Tardif D, Roseau G, Chaussade S, Couturier D, Dubuisson JB. Results and role of rectal endoscopic ultrasonography for patients with deep pelvic endometriosis. *Hum Reprod* 1998; **13**:2266–2270.
- Chapron C, Fauconnier A, Vieira M, Barakat H, Dousset B, Pansini V, Vacher-Lavenu MC, Dubuisson JB. Anatomical distribution of deeply infiltrating endometriosis: surgical implications and proposition for a classification. *Hum Reprod* 2003; **18**:157–161.
- Chapron C, Chopin N, Borghese B, Malartic C, Decuyper F, Foulot H. Surgical management of deeply infiltrating endometriosis: an update. *Ann N Y Acad Sci* 2004; **1034**:326–337. Review.
- Chapron C, Chopin N, Borghese B, Foulot H, Dousset B, Vacher-Lavenu MC, Vieira M, Hasan W, Bricou A. Deeply infiltrating endometriosis: pathogenetic implications of the anatomical distribution. *Hum Reprod* 2006; **21**:1839–1845.
- Chapron C, Pietin-Vialle C, Borghese B, Davy C, Foulot H, Chopin N. Associated ovarian endometrioma is a marker for greater severity of deeply infiltrating endometriosis. *Fertil Steril* 2009; **92**:453–457.
- Chapron C, Bourret A, Chopin N, Dousset B, Leconte M, Amsellem-Ouazana D, de Ziegler D, Borghese B. Surgery for bladder endometriosis: long-term results and concomitant management of associated posterior deep lesions. *Hum Reprod* 2010; **25**:884–889.
- Chapron C, Santulli P, de Ziegler D, Noel JC, Anaf V, Streuli I, Foulot H, Souza C, Borghese B. Ovarian endometrioma: severe pelvic pain is associated with deeply infiltrating endometriosis. *Hum Reprod* 2012; **27**:702–711.
- Cohen J, Thomassin A, Mathieu d'Argent E, Laas E, Canlorbe G, Zilberman S, Belghiti J, Thomassin-Naggara I, Bazot M, Ballester M *et al*. Fertility before and after surgery for deep infiltrating endometriosis with and without bowel involvement: a literature review. *Minerva Gynecol* 2014; **66**:575–587.
- Coronado C, Franklin RR, Lotze EC, Bailey HR, Valdés CT. Surgical treatment of symptomatic colorectal endometriosis. *Fertil Steril* 1990; **53**:411–446.
- Darai E, Thomassin I, Barranger E, Detchev R, Cortez A, Houry S, Bazot M. Feasibility and clinical outcome of laparoscopic colorectal resection for endometriosis. *Am J Obstet Gynecol* 2005; **192**:394–400.
- Darai E, Ackerman G, Bazot M, Rouzier R, Dubernard G. Laparoscopic segmental colorectal resection for endometriosis: limits and complications. *Surg Endosc* 2007a; **21**:1572–1577.
- Darai E, Bazot M, Rouzier R, Houry S, Dubernard G. Outcome of laparoscopic colorectal resection for endometriosis. *Curr Opin Obstet Gynecol* 2007b; **19**:308–313. Review.
- Darai E, Bazot M, Rouzier R, Coutant C, Ballester M. Colorectal endometriosis and fertility. *Gynecol Obstet Fertil* 2008; **36**:1214–1247. Review.
- de Almeida A, Fernandes LF, Averbach M, Abrão MS. Disc resection is the first option in the management of rectal endometriosis for unifocal lesions with less than 3 centimeters of longitudinal diameter. *Surg Technol Int* 2014; **24**:243–248.
- De Cicco C, Corona R, Schonman R, Mailova K, Ussia A, Koninckx P. Bowel resection for deep endometriosis: a systematic review. *BJOG* 2011; **118**:285–291.
- De Ziegler D, Borghese B, Chapron C. Endometriosis and infertility: pathophysiology and management. *Lancet* 2010; **376**:730–738.
- De Ziegler D, Streuli MI, Borghese B, Bajouh O, Abrao M, Chapron C. Infertility and endometriosis: a need for global management that optimizes the indications for surgery and ART. *Minerva Gynecol* 2011; **63**:365–373.
- Di Donato N, Seracchioli R. How to evaluate adenomyosis in patients affected by endometriosis? *Minim Invasive Surg* 2014; **2014**:507230.
- Donnez J, Squifflet J. Complications, pregnancy and recurrence in a prospective series of 500 patients operated on by the shaving technique for deep rectovaginal endometriotic nodules. *Hum Reprod* 2010; **25**:1949–1958.
- Dousset B, Leconte M, Borghese B, Millischer AE, Roseau G, Arkwright S, Chapron C. Complete surgery for low rectal endometriosis: long-term results of a 100-case prospective study. *Ann Surg* 2010; **251**:887–895.
- Dubernard G, Piketty M, Rouzier R, Houry S, Bazot M, Darai E. Quality of life after laparoscopic colorectal resection for endometriosis. *Hum Reprod* 2006; **21**:1243–1247.
- Dubernard G, Rouzier R, David-Montefiori E, Bazot M, Darai E. Use of the SF-36 questionnaire to predict quality-of-life improvement after laparoscopic colorectal resection for endometriosis. *Hum Reprod* 2008; **23**:846–851.
- Duepree 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**:754–748.
- ENDORE – WCE Sao Paolo 2014. Functional Outcomes of Surgical Management of Deep Endometriosis Infiltrating the Rectum: <http://clinicaltrials.gov/ct2/show/NCT01291576?term=NCT01291576&rank=1>.
- English J, Sajid MS, Lo J, Hudelist G, Baig MK, Miles WA. Limited segmental rectal resection in the treatment of deeply infiltrating rectal endometriosis: 10 years' experience from a tertiary referral unit. *Gastroenterol Rep (Oxf)* 2014; **2**:288–294.
- Exacoustos C, Malzoni M, Di Giovanni A, Lazzeri L, Tosti C, Petraglia F, Zupi E. Ultrasound mapping system for the surgical management of deep infiltrating endometriosis. *Fertil Steril* 2014; **102**:143–150.e2.
- Fanfani F, Fagotti A, Gagliardi ML, Ruffo G, Ceccaroni M, Scambia G, Minelli L. Discoid or segmental rectosigmoid resection for deep infiltrating endometriosis: a case-control study. *Fertil Steril* 2010; **94**:444–449.
- Fauconnier A, Chapron C. Endometriosis and pelvic pain: epidemiological evidence of the relationship and implications. *Hum Reprod Update* 2005; **11**:595–606.
- Fedele L, Bianchi S, Zanconato G, Bettoni G, Gotsch F. Long-term follow-up after conservative surgery for rectovaginal endometriosis. *Am J Obstet Gynecol* 2004; **190**:1020–1024.
- Ferrero S, Anserini P, Abbamonte LH, Ragni N, Camerini G, Remorgida V. Fertility after bowel resection for endometriosis. *Fertil Steril* 2009a; **92**:41–46.
- Ferrero S, Camerini G, Menada MV, Biscaldi E, Ragni N, Remorgida V. Uterine adenomyosis in persistence of dysmenorrhea after surgical excision of pelvic endometriosis and colorectal resection. *J Reprod Med* 2009b; **54**:366–372.
- Ferrero S, Camerini G, Ragni N, Venturini PL, Biscaldi E, Remorgida V. Norethisterone acetate in the treatment of colorectal endometriosis: a pilot study. *Hum Reprod* 2010; **25**:94–100.
- Ford J, English J, Miles WA, Giannopoulos T. Pain, quality of life and complications following the radical resection of rectovaginal endometriosis. *BJOG* 2004; **111**:353–356.
- Fourquet J, Báez L, Figueroa M, Iriarte RI, Flores I. Quantification of the impact of endometriosis symptoms on health-related quality of life and work productivity. *Fertil Steril* 2011; **96**:107–112.
- 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.
- Goncalves MO, Podgaec S, Dias JA Jr, Gonzalez M, Abrao MS. Transvaginal ultrasonography with bowel preparation is able to predict the number of lesions and rectosigmoid layers affected in cases of deep endometriosis, defining surgical strategy. *Hum Reprod* 2010; **25**:665–671.
- Guerriero S, Ajossa S, Gerada M, Virgilio B, Angioni S, Melis GB. Diagnostic value of transvaginal 'tenderness-guided' ultrasonography for the prediction of location of deep endometriosis. *Hum Reprod* 2008; **23**:2452–2457.

- Haggag H, Solomayer E, Juhasz-Böss I. The treatment of rectal endometriosis and the role of laparoscopic surgery. *Curr Opin Obstet Gynecol* 2011;**23**:278–282.
- Hudelist G, Tuttlies F, Rauter G, Pucher S, Keckstein J. Can transvaginal sonography predict infiltration depth in patients with deep infiltrating endometriosis of the rectum? *Hum Reprod* 2009;**24**:1012–1017.
- Jacobson TZ, Duffy JM, Barlow D, Koninckx PR, Garry R. Laparoscopic surgery for pelvic pain associated with endometriosis. *Cochrane Database Syst Rev* 2009:CD001300.
- Jerby BL, Kessler H, Falcone T, Milson JW. Laparoscopic management of colorectal endometriosis. *Surg Endosc* 1999;**13**:1125–1158.
- Jess T, Frisch M, Jørgensen KT, Pedersen BV, Nielsen NM. Increased risk of inflammatory bowel disease in women with endometriosis: a nationwide Danish cohort study. *Gut* 2012;**61**:1279–1283.
- Kamergorodsky G, Ribeiro PA, Galvão MA, Abrão MS, Donadio N, Lemos NL, Aoki T. Histologic classification of specimens from women affected by superficial endometriosis, deeply infiltrating endometriosis, and ovarian endometriomas. *Fertil Steril* 2009;**92**:2074–2077.
- Kavallaris A, Köhler C, Kühne-Heid R, Schneider A. Histopathological extent of rectal invasion by rectovaginal endometriosis. *Hum Reprod* 2003;**18**:1323–1327.
- Keckstein J, Wiesinger H. Deep endometriosis, including intestinal involvement—the interdisciplinary approach. *Minim Invasive Ther Allied Technol* 2005;**14**:160–166.
- Koninckx PR, Ussia A, Adamyan L, Wattiez A, Donnez J. Deep endometriosis: definition, diagnosis, and treatment. *Fertil Steril* 2012;**98**:564–571.
- Laas E, Zacharopoulou C, Montanari G, Seracchioli R, Abrão MS, Bassi MA, Ballester M, Darai E. External validation of the SF-36 quality-of-life questionnaire in Italian and Brazilian populations to select patients with colorectal endometriosis for surgery. *J Minim Invasive Gynecol* 2014;**4650**:308–302.
- Landi S, Ceccaroni M, Perutelli A, Allodi C, Barbieri F, Fiaccavento A, Ruffo G, McVeigh E, Zanolla L, Minelli L. Laparoscopic nerve-sparing complete excision of deep endometriosis: is it feasible? *Hum Reprod* 2006;**21**:774–781.
- Lazzeri L, Di Giovanni A, Exacoustos C, Tosti C, Pinzauti S, Malzoni M, Petraglia F, Zupi E. Preoperative and postoperative clinical and transvaginal ultrasound findings of adenomyosis in patients with deep infiltrating endometriosis. *Reprod Sci* 2014;**21**:1027–1033.
- Li HJ, Leng JH, Lang JH, Wang HL, Liu ZF, Sun DW, Zhu L, Ding XM. Correlative factors analysis of recurrence of endometriosis after conservative surgery. *Zhonghua Fu Chan Ke Za Zhi* 2005;**40**:13–16.
- Littman E, Giudice L, Lathi R, Berker B, Milki A, Nezhat C. Role of laparoscopic treatment of endometriosis in patients with failed *in vitro* fertilization cycles. *Fertil Steril* 2005;**84**:1574–1578.
- Maas K, Moriya Y, Kenter G, Trimbos B, van de Velde C. A plea for preservation of the pelvic autonomic nerves. *Lancet* 1999;**354**:772–773.
- Mabrouk M, Montanari G, Guerrini M, Villa G, Solfrini S, Vicenzi C, Mignemi G, Zannoni L, Frasca C, Di Donato N et al. Does laparoscopic management of deep infiltrating endometriosis improve quality of life? A prospective study. *Health Qual Life Outcomes* 2011;**9**:98.
- Mangler M, Loddenkemper C, Lanowska M, Bartley J, Schneider A, Köhler C. Histopathology-based combined surgical approach to rectovaginal endometriosis. *Int J Gynaecol Obstet* 2008;**103**:59–64.
- Mechsner S, Weichbrodt M, Riedlinger WF, Kaufmann AM, Schneider A, Köhler C. Immunohistochemical evaluation of endometriotic lesions and disseminated endometriosis-like cells in incidental lymph nodes of patients with endometriosis. *Fertil Steril* 2010;**94**:457–463.
- Meuleman C, d'Hoore A, Van Cleynenbreugel B, Beks N, d'Hooghe T. Outcome after multidisciplinary CO2 laser laparoscopic excision of deep infiltrating colorectal endometriosis. *Reprod Biomed Online* 2009;**18**:282–289.
- Meuleman C, Tomassetti C, D'Hoore A, Van Cleynenbreugel B, Penninckx F, Vergote I, D'Hooghe T. Surgical treatment of deeply infiltrating endometriosis with colorectal involvement. *Hum Reprod Update* 2011;**17**:311–326.
- Meuleman C, Tomassetti C, Wolthuis A, Van Cleynenbreugel B, Laenen A, Penninckx F, Vergote I, D'Hoore A, D'Hooghe T. Clinical outcome after radical excision of moderate-severe endometriosis with or without bowel resection and reanastomosis: a prospective cohort study. *Ann Surg* 2014;**259**:522–531.
- Minelli L, Fanfani F, Fagotti A, Ruffo G, Ceccaroni M, Mereu L, Landi S, Pomini P, Scambia G. Laparoscopic colorectal resection for bowel endometriosis: feasibility, complications, and clinical outcome. *Arch Surg* 2009;**144**:234–239.
- Moawad NS, Caplin A. Diagnosis, management, and long-term outcomes of rectovaginal endometriosis. *Int J Womens Health* 2013;**5**:753–763. Review.
- Moawad NS, Guido R, Ramanathan R, Mansuria S, Lee T. Comparison of laparoscopic anterior discoid resection and laparoscopic low anterior resection of deep infiltrating rectosigmoid endometriosis. *JLS* 2011;**15**:331–338.
- Mohr C, Nezhat FR, Nezhat CH, Seidman DS, Nezhat CR. Fertility consideration in laparoscopic treatment of infiltrative bowel endometriosis. *J Soc Laparosc Surg* 2005;**9**:16–24.
- Nirgianakis K, McKinnon B, Imboden S, Knabben L, Gloor B, Mueller MD. Laparoscopic management of bowel endometriosis: resection margins as a predictor of recurrence. *Acta Obstet Gynecol Scand* 2014;**93**:1262–1267.
- Noël JC, Chapron C, Fayt I, Anaf V. Lymph node involvement and lymphovascular invasion in deep infiltrating rectosigmoid endometriosis. *Fertil Steril* 2008;**89**:1069–1072.
- Noël JC, Chapron C, Bucella D, Buxant F, Peny MO, Fayt I, Borghese B, Anaf V. Estrogen and progesterone receptors in smooth muscle component of deep infiltrating endometriosis. *Fertil Steril* 2010;**93**:1774–1747.
- Oliveira MA, Crispi C, Oliveira FM, Junior PS, Raymundo TS, Pereira TD. Double circular stapler technique for bowel resection in rectosigmoid endometriosis. *J Minim Invasive Gynecol* 2014;**21**:136–141.
- Pagidas K, Falcone T, Hemmings R, Miron P. Comparison of reoperation for moderate (stage III) and severe (stage IV) endometriosis-related infertility with *in vitro* fertilization-embryo transfer. *Fertil Steril* 1996;**65**:791–795.
- Panebianco V, Poli A, Blandino R, Pistrutto A, Puzzo L, Grasso A, Petino AG. Low anterior resection of the rectum using mechanical anastomosis in intestinal endometriosis. *Minerva Chir* 1994;**49**:215–217.
- Pereira RM, Zanatta A, Preti CD, de Paula FJ, da Motta EL, Serafini PC. Should the gynecologist perform laparoscopic bowel resection to treat endometriosis? Results over 7 years in 168 patients. *J Minim Invasive Gynecol* 2009;**16**:472–479.
- Piketny M, Chopin N, Dousset B, Millischer-Bellaische AE, Roseau G, Leconte M, Borghese B, Chapron C. Preoperative work-up for patients with deeply infiltrating endometriosis: transvaginal ultrasonography must definitely be the first-line imaging examination. *Hum Reprod* 2009;**24**:602–607.
- Possover M, Diebolder H, Plaul K, Schneider A. Laparoscopically assisted vaginal resection of rectovaginal endometriosis. *Obstet Gynecol* 2000;**96**:304–307.
- 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**:913–917.
- Pronio A, Di Filippo A, Narilli P, Mancini B, Caporilli D, Piroli S, Vestri A, Montesani C. Anastomotic dehiscence in colorectal surgery. Analysis of 1290 patients. *Chir Ital* 2007;**59**:599–609.
- Razzi S, Luisi S, Calonaci F, Altomare A, Bocchi C, Petraglia F. Efficacy of vaginal danazol treatment in women with recurrent deeply infiltrating endometriosis. *Fertil Steril* 2007;**88**:789–794.
- Redwine DB, Wright JT. Laparoscopic treatment of complete obliteration of the cul-de-sac associated with endometriosis: long-term follow-up of en bloc resection. *Fertil Steril* 2001;**76**:358–365.
- Reich H. Laparoscopic surgery for bowel endometriosis. *Surg Technol Int* 1997;**6**:199–206.
- Remorgida V, Ragni N, Ferrero S, Anserini P, Torelli P, Fulcheri E. How complete is full thickness disc resection of bowel endometriotic lesions? A prospective surgical and histological study. *Hum Reprod* 2005;**20**:2317–2320.
- Remorgida V, Ferrero S, Fulcheri E, Ragni N, Martin DC. Bowel endometriosis: presentation, diagnosis, and treatment. *Obstet Gynecol Surv* 2007;**62**:461–470. Review.
- Rocha AL, Reis FM, Petraglia F. New trends for the medical treatment of endometriosis. *Expert Opin Investig Drugs* 2012;**21**:905–919.
- Roman H, Loisel C, Resch B, Tuech JJ, Hochain P, Leroi AM, Marpeau L. Delayed functional outcomes associated with surgical management of deep rectovaginal endometriosis with rectal involvement: giving patients an informed choice. *Hum Reprod* 2010;**25**:890–899.
- Roman H, Tuech JJ. Laparoscopic and transanal excision of large lower- and mid-rectal deep endometriotic nodules: the Rouen technique. *Fertil Steril* 2014a;**102**:e7.
- Roman H, Tuech JJ. New disc excision procedure for low and mid rectal endometriosis nodules using combined transanal and laparoscopic approach. *Colorectal Dis* 2014b;**16**:O253–256.
- Roman H, Vassilief M, Gourcerol G, Savoye G, Leroi AM, Marpeau L, Michot F, Tuech JJ. Surgical management of deep infiltrating endometriosis of the rectum: pleading for a symptom-guided approach. *Hum Reprod* 2011;**26**:274–281.
- Roman H, Ness J, Suci N, Bridoux V, Gourcerol G, Leroi AM, Tuech JJ, Ducrotté P, Savoye-Collet C, Savoye G. Are digestive symptoms in women presenting with

- pelvic endometriosis specific to lesion localizations? A preliminary prospective study. *Hum Reprod* 2012;**27**:3440–3449.
- Roman H, Vassilief M, Tuech JJ, Huet E, Savoye G, Marpeau L, Puscasiu L. Postoperative digestive function after radical versus conservative surgical philosophy for deep endometriosis infiltrating the rectum. *Fertil Steril* 2013;**99**:1695–1704.
- Roman H, Tuech JJ, Arambage K. Deep rectal shaving followed by transanal disc excision in large deep endometriosis of the lower rectum. *J Minim Invasive Gynecol* 2014;**21**:730–731.
- 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**:63–67.
- Ruffo G, Sartori A, Crippa S, Partelli S, Barugola G, Manzoni A, Steinasserer M, Minelli L, Falconi M. Laparoscopic rectal resection for severe endometriosis of the mid and low rectum: technique and operative results. *Surg Endosc* 2012;**26**:1035–1040.
- Sampson JA. Peritoneal endometriosis due to the menstrual dissemination of endometrial tissue into the peritoneal cavity. *Am J Obstet Gynecol* 1927;**14**:422–469.
- Seracchioli R, Poggioli G, Pierangeli F, Manuzzi L, Gualerzi B, Savelli L, Remorgida V, Mabrouk M, Venturoli S. Surgical outcome and long-term follow up after laparoscopic rectosigmoid resection in women with deep infiltrating endometriosis. *BJOG* 2007;**114**:889–895.
- Seracchioli R, Mabrouk M, Manuzzi L, Vicenzi C, Frascà C, Elmakky A, Venturoli S. post-operative use of oral contraceptive pills for prevention of anatomical relapse or symptom-recurrence after conservative surgery for endometriosis. *Hum Reprod* 2009;**24**:2729–2735.
- Sibiude J, Santulli P, Marcellin L, Borghese B, Dousset B, Chapron C. Association of history of surgery for endometriosis with severity of deeply infiltrating endometriosis. *Obstet Gynecol* 2014;**124**:709–717.
- Somigliana E, Vercellini P, Gattei U, Chopin N, Chiodo I, Chapron C. Bladder endometriosis: getting closer and closer to the unifying metastatic hypothesis. *Fertil Steril* 2007;**87**:1287–1290.
- The Practice Committee of the American Society for Reproductive Medicine. Endometriosis and Infertility. *Fertil Steril* 2006;**86**:S156–S160.
- Thomassin I, Bazot M, Detchev R, Barranger E, Cortez A, Darai E. Symptoms before and after surgical removal of colorectal endometriosis that are assessed by magnetic resonance imaging and rectal endoscopic sonography. *Am J Obstet Gynecol* 2004;**190**:1264–1271.
- Tran KT, Kuijpers HC, Willemsen WN, Bulten H. Surgical treatment of symptomatic rectosigmoid endometriosis. *Eur J Surg* 1996;**162**:139–141.
- Trencheva K, Morrissey KP, Wells M. Identifying important predictors for anastomotic leak after colon and rectal resection: prospective study on 616 patients. *Ann Surg* 2013;**257**:108–113.
- Tuttles F, Keckstein J, Ulrich U, Possover M, Schweppe KW, Wustlich M, Buchweitz O, Greb R, Kandolf O, Mangold R et al. ENZIAN-score, a classification of deep infiltrating endometriosis. *Zentralbl Gynakol* 2005;**127**:275–281.
- van Dijk LJ, Nelen WL, d'Hooghe TM, Dunselman GA, Hermens RP, Bergh C, Nygren KG, Simons AH, de Sutter P, Marschall C et al. The European Society of Human Reproduction and Embryology guideline for the diagnosis and treatment of endometriosis: an electronic guideline implementability appraisal. *Implement Sci* 2011;**6**:7.
- Vercellini P, Fedele L, Aimi G, De Giorgi O, Consonni D, Crosignani PG. Reproductive performance, pain recurrence and disease relapse after conservative surgical treatment for endometriosis: the predictive value of the current classification system. *Hum Reprod* 2006;**21**:2679–2685.
- Vercellini P, Crosignani PG, Abbiati A, Somigliana E, Viganò P, Fedele L. The effect of surgery for symptomatic endometriosis: the other side of the story. *Hum Reprod Update* 2009a;**15**:177–188.
- Vercellini P, Barbara G, Abbiati A, Somigliana E, Viganò P, Fedele L. Repetitive surgery for recurrent symptomatic endometriosis: what to do? *Eur J Obstet Gynecol Reprod Biol* 2009b;**146**:15–21.
- Vercellini P, Somigliana E, Viganò P, De Matteis S, Barbara G, Fedele L. The effect of second-line surgery on reproductive performance of women with recurrent endometriosis: a systematic review. *Acta Obstet Gynecol Scand* 2009c;**88**:1074–1082.
- Vercellini P, Somigliana E, Viganò P, De Matteis S, Barbara G, Fedele L. Post-operative endometriosis recurrence: a plea for prevention based on pathogenetic, epidemiological and clinical evidence. *Reprod Biomed Online* 2010;**21**:259–265.
- 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**:389–395.
- Vignali M, Bianchi S, Candiani M, Spadaccini G, Oggioni G, Busacca M. Surgical treatment of deep endometriosis and risk of recurrence. *J Minim Invasive Gynecol* 2005;**12**:508–513.
- Wills HJ, Reid GD, Cooper MJ, Morgan M. Fertility and pain outcomes following laparoscopic segmental bowel resection for colorectal endometriosis: a review. *Aust N Z J Obstet Gynaecol* 2008;**48**:292–295.
- Zanardi R, Del Frate C, Zuiani C, Bazzocchi M. Staging of pelvic endometriosis based on MRI findings versus laparoscopic classification according to the American Fertility Society. *Abdom Imaging* 2003;**28**:733–742.