



Laparoscopic excision of deeply infiltrating endometriosis: a prospective observational study assessing perioperative complications in 244 patients

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Abstract

Purpose To examine peri-operative complications in patients undergoing laparoscopic excision of deeply infiltrating endometriosis (DIE).

Methods This was a prospective study of a case series of women having laparoscopic excision of deeply infiltrating endometriosis from September 2013 through August 2016 in a tertiary referral center for endometriosis and minimally invasive gynaecological surgery in Iran. Data collected included demographics, baseline characteristics, intraoperative and postoperative data up to 1 month following surgery.

Results We analysed data from 244 consecutive patients, who underwent radical laparoscopic excision of all visible DIE. Major postoperative complications occurred in 3 (1.2%) and minor complications in 27 (11.1%) of patients. 80.3% of our patient group had Stage IV endometriosis. Segmental bowel resection was performed in 34 (13.9%), disc resection in 7 (2.9%), rectal shave in 53 (21.7%). Joint operating between a gynaecologist and colorectal and/or urological colleague was required in 29.6% of cases. The mean operating time was 223.8 min (± 80.7 standard deviation, range 60–440 min) and mean hospital stay was 2.9 days (± 1.5 standard deviation, range 1–11). The conversion to laparotomy rate was 1.6%.

Conclusions A combination of different laparoscopic surgical techniques to completely excise all visible DIE, within the context of a tertiary referral center offering multi-disciplinary approach, produces safe outcomes with low complication rates.

Keywords Laparoscopic treatment of endometriosis · Deeply infiltrating endometriosis · Recto-vaginal endometriosis · Surgical complications · Multi-disciplinary team

Introduction

Endometriosis is characterized by the presence of endometrial glands and stroma outside the uterus. It is a leading cause of chronic pelvic pain and infertility affecting between 10 and 15% of women of reproductive age and up to 50% of women with infertility [1].

Deep infiltrating endometriosis (DIE) describes lesions, which infiltrate the peritoneum at a depth of more than 5 mm and it is found in 20% of cases [2]. It can involve the uterosacral ligaments (USL), the pouch of Douglas, the recto-vaginal septum and rectum and the bladder and ureter. The disease manifests usually as a combination of symptoms depending on the affected organs. Medical treatment can improve symptoms; however, these recur after discontinuation [3]. In rare cases, obstruction of the ureter can compromise renal function [4]. Laparoscopy remains the

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gold standard for the diagnosis and treatment of DIE [5]. Laparoscopic excision of DIE, particularly gastrointestinal disease, represents one of the most challenging procedures in gynaecological surgery. In the UK, the National Institute for Health and Care Excellence (NICE) has recently published guidance on the management of endometriosis, promoting centralization of care for patients with complex disease and DIE [6]. A number of case series undergoing laparoscopic treatment for DIE in tertiary referral centers offering multi-disciplinary team (MDT) approach have been published so far. Reported complication rates vary between different surgical teams but also depend on the type of procedure performed and in particular varies depending on the complexity of the patient group [7–9].

In the present study, we report our data from the first series of patients with DIE treated in our tertiary referral unit, the Avicenna Centre for Endometriosis and Minimally Invasive Gynaecology (ACEMIG), Tehran, Iran. We examined baseline characteristic and analysed rates of intra- and postoperative complications.

Patients and methods

This was a prospective observational study. Our series included all women ($n=244$) aged 15–55 who underwent laparoscopic surgery for DIE at ACEMIG (Tehran, Iran) between September 2013 and August 2016. ACEMIG is one of very few referral centers for women with severe endometriosis in Iran and achieved accreditation as an endometriosis center by the British Society of Gynaecological Endoscopy (BSGE) in 2015. 170 of our 244 patients were included in a recent publication that reported on the outcome of 5162 patients with endometriosis from all BSGE centres over 8 years [10].

ACEMIG core surgical team consisted of four postgraduate fellows undertaking training in advanced endometriosis surgery under the supervision of the lead surgeon (SK) who is based in the United Kingdom and traveled periodically to Tehran to teach and perform endometriosis surgery during the study period. There is a dedicated specialist nurse and the team has access to the ARI research team and works closely with other disciplines including fertility experts, pain specialists, radiologists, urologists and colorectal surgeons all experienced in endometriosis.

Patients are seen in a dedicated endometriosis clinic by one of four fellows (KS, RP, AG and RK). Demographic characteristics, examination and imaging findings are recorded electronically in a cloud-based database accessible by the lead surgeon who advises on management plan. Patients are typically seen multiple times by the team and will also see the urologists and colorectal surgeons if required. All candidates for surgery will also have a video

consultation with the lead surgeon before they are scheduled for their procedure.

The inclusion criteria for this study included pre-menopausal status, known or suspected endometriosis associated with at least one symptom of pelvic pain (dysmenorrhea, dyspareunia, non-cyclical pain, dyschezia) with or without associated infertility and consent to be followed up postoperatively. All procedures were performed or directly supervised by a single lead surgeon (SK).

Preoperative assessment included a clinical examination and a pelvic ultrasound scan for all patients. All women with suspected or proven DIE affecting the bowel, bladder or ureter were further assessed with endo-anal sonography (EUS) and/or magnetic resonance imaging (MRI). All women were counselled about the risks of surgery for DIE on multiple occasions and were provided written information. Written consent was obtained prior to surgery. All women with DIE involving the bowel had a 2-day bowel preparation preoperatively.

All patients received general anaesthesia with endotracheal intubation. The surgical approach consisted of four laparoscopic ports (one 10 mm umbilical port, two 5 mm lateral accessory ports inserted into the right and left lower quadrants and one 5 mm accessory supra-pubic port). Open entry technique was used in all but one cases. The surgical procedures employed to excise DIE included: segmental bowel resection, disc bowel excision, shaving of recto-vaginal nodule, en-bloc excision of the “butterfly” area, excision of uterosacral ligaments (USL), ureterolysis and excision of vaginal and bladder nodules.

Shaving technique was used where the disease had not infiltrated into the bowel muscularis or when the infiltration was superficial and, therefore, all the visible disease could be completely excised without opening the rectal lumen. Bowel resection was considered for symptomatic patients with deep infiltrating endometriosis involving the deep rectal/sigmoid muscularis layer associated with either a single nodule of more than 3 cm in diameter, or multiple nodules, or nodule(s) causing bowel stricture. Disc resection was considered for symptomatic patients with deep infiltrating endometriosis involving the deep rectal/sigmoid muscularis layer associated with an isolated single nodule of less than 3 cm diameter. The final decision was always taken jointly with the colorectal surgeon at the time of surgery, having seen and palpated the nodule vaginally, rectally and laparoscopically, and having assessed the presence or lack of stricture.

We defined the “excision of the butterfly area” as bilateral excision of the peritoneum of the ovarian fossa and pelvic sidewall (the wings), the uterosacral ligaments (stem of the wing) and the torus uterinus and pouch of Douglas (the body of the butterfly).

Our group has previously described the en-bloc excision of the “butterfly” area for DIE (<https://bsge.org.uk/video/excision-butterfly-area-sosure-resection/>). We have

suggested the acronym “SO SURE” to describe the surgical steps, which include: survey and Sigmoid mobilization, Ovarian mobilization, temporary Suspension of ovaries and uterus, Ureterolysis, Rectovaginal septum entry, Entry into pararectal spaces and Resection of all visible disease. In cases of DIE affecting the bowel, the procedure performed was chosen based on the extent of rectal wall infiltration by the disease, the position and number of the nodules and the symptoms and wishes of the patient. In cases of nodules with possible or proven ureteral involvement, the ureters were stented. When necessary, extensive adhesiolysis was performed to free the uterus and adnexae and mobilise the recto-sigmoid. In cases of recto-vaginal nodules, the pararectal spaces were dissected. When the endometriotic nodule infiltrated the full thickness of the vaginal wall, the affected part of the vagina was excised and the defect was repaired laparoscopically. Excision of endometriomata was performed when present. At the end of the procedures requiring rectal surgery, the integrity of the rectal wall/anastomosis was checked with the Michelin test as well as methylen blue test. The peritoneal cavity was filled with normal saline, the sigmoid was occluded and air was insufflated into the rectum to detect leakage. If negative, 120 mL of methylene blue was pushed into the rectum to look for smaller, higher or posterior defects. When required, colorectal and/or urological surgeons took part in the above procedures jointly with the gynaecological surgeons.

The main energy sources used for our procedures were bipolar and ultrasonic energy. We tend to use judicious amount of bipolar diathermy and cold scissors for most of the dissection. Ultrasonic energy is normally used for excision of the tissue, having dissected the relevant anatomical spaces.

Primary outcomes were intra- and postoperative complications. Postoperative fever was defined as body temperature of 38 °C or above on two occasions at least 6 h apart, during the first 24 postoperative hours. Pre- and postoperative data were also collected on severity of painful symptoms (pain scores for dysmenorrhea, dyspareunia, cyclical and non-cyclical pain, dyschezia). The focus of this study was to report on peri-operative complications and not symptomatic patient outcomes.

All procedures were video recorded and all videos were reviewed to confirm, complete and validate the operation details.

Results

The data from 244 women were analyzed. Mean age and parity were 31.8 and 0.5, respectively (range 15–55 and 0–3, respectively). Baseline characteristic data are shown in Table 1 and presenting symptoms in Table 2. The most

Table 1 Baseline characteristics of the study population

	<i>n</i> (%)	Mean (SD)
Age		31.8 (6.4)
BMI (kg/m ²)		23.5 (3.7)
Parity		
0	153(62.7)	
1	53 (21.7)	
2	20 (8.2)	
3	18 (7.4)	
Primary infertility	76 (31.1)	
Male factor infertility	11 (4.5)	
Secondary infertility	41 (16.8)	
Endometriosis stage (rASRM)		
I	7 (2.9)	
II	13 (5.3)	
III	28 (11.5)	
IV	196 (80.3)	

Table 2 Presenting symptoms

	<i>n</i> (%)
Pelvic pain	244 (100)
Infertility	117 (62.2)
Dysfunctional uterine bleeding	85 (34.8)
Constipation	64 (26.2)
Bloating	55 (22.5)
Frequency	40 (16)
Diarrhea	34 (13.9)
Dysuria	26 (10.7)
Rectal bleeding	11 (4.5)
Renal angle pain	8 (3.3)
Haematuria	1 (0.4)

common presenting symptom was pelvic pain (including cyclical and non-cyclical pelvic pain, dysmenorrhea, dyschezia and dyspareunia). Of the 244 patients, 16 (6.6%) presented with one symptom only, 85 (34.8%) presented with two symptoms and the remaining 143 (58.6%) presented with three or more symptoms. The median VAS score for dysmenorrhea pre-operatively was 8/10.

Infertility affected 52.4% of our patients. Of these, 76 had primary infertility (31.1%), 41 secondary (16.8%) and 11 couples had male factor infertility (4.5%). One hundred patients (41%) had at least one previous operation where endometriosis was ablated or excised incompletely. The mean length of stay in hospital following surgery was 2.9 ± 1.5 days (range 1–11 days). Histology confirmed endometriosis in 236/244 (96%) cases. In three

(1.2%) cases pathology did not confirm endometriosis. five pathology reports (2%) were missing.

Of our 244 patients, 196 (80.3%) had stage IV endometriosis according to the rASRM classification. 100 patients (41%) had at least one previous procedure (either laparoscopy or laparotomy) where endometriosis was ablated or incompletely excised. Bilateral or unilateral hydronephrosis was noted in 15/244 cases (6.1%) and hydroureter was seen in two cases (0.8%). In cases of DIE affecting the rectosigmoid, we found 16 cases with two distinct nodules, four cases with three nodules and one patient with four nodules in EUS.

Intraoperative data

The mean operating time was 223.8 ± 80.7 min (range 60–440 min). Some steps of the procedures were typically performed by one of four fellows, supervised by SK, depending on the complexity of the case and competence of the fellow. The mean hemoglobin drop was 1.5 ± 1.1 g/dL. The conversion to laparotomy rate was 1.6%, with 240/244 patients having their procedures completed laparoscopically. One laparotomy was performed as we encountered extraordinary and unusual stony hard fibrosis. One laparotomy was performed to repair small bowel injury at multiple locations caused by Veress needle during a Palmer's point entry. This loop of small bowel was densely adhered right under the palmer's point. Two laparotomies were deemed necessary by the colorectal surgeon for the completion of segmental bowel resections. Another conversion was done to resect an endometriotic nodule involving the cecum and terminal ileum.

There were no cases receiving primary laparotomy in our series. At the time of surgery, 196/244 patients (80.3%) were diagnosed with stage IV, 28/244 (11.5%) with stage III and the rest 20/244 with stage I–II endometriosis according to the rASRM classification (Table 1). The specific surgical procedures performed are shown in Table 3. Assistance of a colorectal and/or a urological surgeon was required in 74/244 (29.6%) cases. The most common procedure for gastrointestinal endometriosis was shaving (53/244 patients, 21.7%), followed by segmental bowel resection (34/244, 13.9%) and disc excision (7/244, 2.7%). Excision of the “Butterfly” area was performed in 99/244 of our patients (40.6%). Stoma formation was deemed necessary only in one case (0.4%). This patient had segmental bowel resection with a low anastomotic line, the vagina was opened. Excision of endometriomata was required for the majority of our patients (170/244, 68%). Excision of USL DIE was done in 97/244 (39.8%), excision of sidewall DIE in 59/244 (24.2%) and extensive adhesiolysis was required for 90/244 (36.9%) patients. Twelve patients had bladder nodules and four patients had vaginal nodules excised (4.9 and 1.6%,

Table 3 Surgical procedures performed

	n (%)
Endometriosis resection (RV segmental)	34 (13.9)
Endometriosis resection (RV disc)	7 (2.9)
Endometriosis resection (RV shave)	53 (21.7)
Endometriosis resection (DIE, butterfly)	99 (40.6)
Endometriosis resection (DIE, USL)	97 (39.8)
Endometriosis resection (DIE, sidewall)	59 (24.2)
Endometriosis resection (DIE, other locations)	43 (17.6)
Endometriosis resection (vaginal nodule)	4 (1.6)
Endometriosis resection (bladder nodule)	12 (4.9)
Endometrioma excision	170 (68)
Other cyst excision	10 (4.1)
Extensive adhesiolysis	90 (36.9)

RV recto-vaginal, DIE deeply infiltrating endometriosis, USL uterosacral ligament

respectively). Total hysterectomy was performed in 16 of our patients (6.6%). Michelin tests showed no cases of bowel wall/anastomosis leaks at the end of our procedures.

Intra-operative complications

Intraoperative complications occurred in four patients (1.6%). There were three bowel injuries (1.2%) and one vascular injury (0.4%). This was an injury of the inferior epigastric artery during trocar insertion managed laparoscopically). All injuries were detected and repaired during the primary surgery. Of the three bowel injuries, two were accidental enterotomies due to the presence of extensive adhesions (sutured laparoscopically—no sequela) and one was multiple small bowel injuries from the veress needle at failed attempts to gain entry at Palmer's point. This patient had a laparotomy due to the presence of extensive bowel adhesions involving the anterior abdominal wall and the veress needle injury that occurred as a result. We had no cases with significant bleeding (estimated blood loss above 500 mL) intra-operatively.

Post-operative complications

Postoperative complications occurred in 30 cases (12.3%), including three major (1.2%) and 27 minor (11.1%) complications. The major complications included: A catastrophic complication in one patient (0.4%) with fatal massive pulmonary thromboembolism within the first 24 h following surgery. The patient had received prophylactic intraoperative heparin and compression stockings had been used during surgery. The hospital at the time did not have access to pneumatic compression stockings. As adhesiolysis seemed impossible due to unusually dense fibrotic tissue cementing

the loops of bowel together to the extent laparoscopic instruments were failing in dividing these adhesions, the general surgical team took over and performed a midline laparotomy. Following extensive adhesiolysis a 10 cm stony hard endometriotic rectovaginal nodule and a further nodule involving the ileum were seen. As the surgery was already prolonged, it was decided that the procedure should be abandoned and bowel resection planned in the proceeding couple of weeks before adhesions reform. The patient developed sudden cardiovascular collapse 16 h postoperatively and did not respond to prolonged cardio pulmonary resuscitation. The autopsy confirmed a saddle pulmonary embolus as cause of death. There was no evidence of bleeding in the pelvis or the abdomen (Tables 4, 5).

We had one case of ureteric injury (0.4%), which was diagnosed during the first postoperative week. The patient was re-admitted to hospital with fever and abdominal pain.

Table 4 Description of all significant perioperative events

	<i>n</i> (%)
Intraoperative events	
Accidental enterotomy (identified and repaired intra-operatively, no sequel)	3 (1.2)
Vascular injury (inferior epigastric artery)	1 (0.4)
Postoperative complications (within 1 week)	
Thromboembolism (fatal pulmonary embolism)	1 (0.4)
Ureteric injury	1 (0.4)
Ileostomy stenosis	1 (0.4)
Haemoglobin drop > 3 g/dL	4 (1.6)
Pyrexia	15 (6)
Retention of urine	1 (0.4)
Cystitis	1 (0.4)
Pain for > 24 h < 5 days	3 (1.2)
Wound infection	2 (0.8)
Anastomotic leaks	0 (0.0)
Postoperative complications (2 weeks to 1 month)	
Cystitis	1 (0.4)
Any fistula	0 (0.0)

Imaging revealed hydronephrosis due to ureteral injury. The patient returned to theatre and had a laparotomy and ureteroneocystostomy by the urology team. This was deemed to be a consequence of thermal injury to the ureter during extensive tissue dissection. Finally, one patient had stenosis of her ileostomy within a week following segmental bowel resection with prophylactic ileostomy. The patient was re-admitted to hospital and was managed by the colorectal team. The rate of readmission to hospital was 0.8%, including the two above patients mentioned. The re-operation rate was also 0.8% representing the same two patients.

There were no anastomotic leakage, no peritonitis and no cases of fistula formation in our series.

We classed the following 27 cases as minor complications because of their minor impact on patients' recovery course. We observed a hemoglobin drop of more than 3gr/dL in four cases (1.6%). We had 15 cases of postoperative pyrexia (6%) all of which resolved following rehydration and administration of paracetamol. Urinary retention was observed in one case only (0.4%) and was managed with re-insertion of Foley catheter for a week. Significant postoperative pain persisting beyond the first 24 postoperative hours (and less than 5 days) was reported by three patients (1.2%). Two cases were complicated by wound infection (0.8%). Cystitis occurred in two cases (0.8%), one during the first postoperative week and one after the first week and within 1 month from surgery. There have been no late onset complications reported, including no rectovaginal or urinary tract fistulas, 30 months following the end of the recruitment period.

Discussion

In this prospective study, we evaluated 244 women who underwent laparoscopic surgery for DIE in the setting of a tertiary referral center with gynaecological, urological, colorectal and radiological expertise in endometriosis. We focused on surgical complications occurring during surgery until one month postoperatively. Our overall major complication rate was 2.8%.

Table 5 Post-operative complications severity according to Clavien-Dindo classification

Grade	%	<i>n</i>	Details
I	8.1	20	Wound infection dealt with as outpatient (<i>n</i> = 2) Pyrexia responding to conservative management (<i>n</i> = 15) Significant Pain > 24 h but < 5 days (<i>n</i> = 3)
II	2.4	6	Hemoglobin drop > 3 g/l requiring transfusion (<i>n</i> = 4) Cystitis or other UTI (<i>n</i> = 2)
IIIa	0.4	1	Urinary retention requiring of Foley Catheter for 1 week
IIIb	0.8	2	Ureteric injury presented postoperatively. Required re-implantation. (<i>n</i> = 1) Stenosis of ileostomy, required revision of ileostomy site (<i>n</i> = 1)
IV	0	0	
V	0.4	1	Massive pulmonary embolism day 1 post-op, resulting in patient's demise

Stage IV endometriosis was found and managed in 80.3% of our cases and 38.5% of our patients required some form of bowel surgery. The proportion of cases operated jointly by a gynaecologist and colorectal and/or urological colleague was 29.6%. The unusual complexity of the casemix reflects the fact that ACEMIG is one of very few tertiary referral centers for severe endometriosis in Iran. Many of these cases (41%) had surgery for endometriosis prior to being referred to our unit. It became clear during the course of our study that in such patients, the disease had been partially treated and attempts to excise endometriosis had been abandoned after extensive tissue dissection. We, therefore, encountered several cases with unusually extensive and dense adhesions and an overall disease burden, which cannot be adequately described by classifying it as stage IV rASRM. We, therefore, agree with authors who suggest that the rASRM classification should be complemented by an additional system, which allows accurate morphological description of DIE, such as Enzian [11].

One of the long-standing arguments among surgical teams managing rectovaginal DIE revolves around the choice of shaving the disease off the bowel versus resecting part of the bowel. Several authors have reported their outcomes but studies are heterogeneous making comparisons difficult.

The reasons for this heterogeneity are multiple. First, there is no consensus regarding the surgical nomenclature. For example, some surgeons consider “shave” to be the removal of part of the endometriotic rectal nodule, leaving some disease or fibrotic tissue on the bowel. Our definition of shave is where complete excision of visible and palpable disease is possible due to lack of deep infiltration into the muscularis. Secondly, there is no widely accepted classification system to sufficiently account for the complexity of disease and therefore surgical risk. For example, complexity and risk of a case with stage IV rASRM disease can vary very widely.

Donnez et al. suggest that shaving techniques carry lower morbidity compared to bowel resection [9]. In their series of 3298 patients operated by nodule shaving, they reported rates of 1.3% for bowel injury and 0.3% for ureteric injury. To our knowledge, this is one of the largest series of DIE cases published to date and the complication rates reported are among the lowest in the literature of DIE.

We used a combination of shaving and bowel resection techniques to excise all visible DIE for our patients, including nodule shaving, disc excision and segmental bowel resection. Our most commonly performed technique (40.6%) was the excision of the “Butterfly area” based on the “SO SURE” principles described in our Methods section. Our rates of bowel and ureter injuries were comparable to those of Donnez et al. (1.2 and 0.4%, respectively). This is in contrast to previous reports quoting rates

of ureteric injuries of up to 1.8% [12–15]. We observed very low rates of urinary retention: 0.4 vs 0.64% reported by Donnez et al. even though our series included several cases of segmental bowel resection [9]. We believe that this was achieved by thorough implementation of clearly defined pathways for postoperative bladder care and a nerve-sparing technique. We had a rather high rate of non-pathologic postoperative pyrexia (6%), compared to the 2.5% rate reported by Kondo et al. [13]. In all these cases, pyrexia resolved with supportive treatment alone. A likely explanation is that our patients required more extensive surgery compared to the case series of Kondo et al. given our higher proportion of patients with stage IV endometriosis (80.3 vs 20.1%).

We observed no cases of anastomotic leakage and no cases of recto-vaginal fistula, having performed prophylactic ileostomy in one case only. The risk of postoperative recto-vaginal fistula is increased when both the rectum and the vagina have been entered and temporary ileostomy or colostomy may be protective in these cases [13]. Rates vary depending on the type of surgery performed. Donnez et al. reported very low rates of anastomotic leakage and fistula (0.06% for both complications) in their series of nodule shavings [14], whereas other authors’ series of bowel resections report rates of 3–5% for leakage and 6–9% for fistula [15–20]. In a recent large series of 364 cases receiving shave, disc excision or segmental resection, Abo et al. reported an overall major postoperative complication rate of 9.3% including 3.6% rectovaginal fistula and 0.3% anastomotic leakage rates [21]. Our low rate of fistula formation and postoperative bowel leak may be explained by our minimal use of diathermy around the bowel. We use mostly cold scissors for shaving and tolerate a small amount of bleeding, which can be controlled by careful and short bursts of point diathermy.

Our conversion to laparotomy rate was 1.6%. Comparisons among different studies are again difficult due to their heterogeneity. As an indication, Kondo et al. observed a 2.3% rate of conversion. Most of their laparotomies were required when colorectal surgeons were involved [13]. Darai et al. reported a case series of 971 women who underwent laparoscopic segmental bowel resection for DIE with a conversion rate of 10% [22].

Given the complexity of the disease, the European Society of Human Reproduction and Embryology has recommended the creation of tertiary referral centers for the treatment of DIE [2]. In the UK, The British Society for Gynaecological Endoscopy (BSGE) introduced the concept of endometriosis centres more than 20 years ago and NICE has adopted this position and recently published relevant guidance [6]. The MDT approach offered in such centers is thought to promote accurate diagnosis and safe management of women with DIE [7, 10, 23].

About one-third of our patients were operated jointly with a colorectal and/or urological colleague. In agreement with national and international recommendations, we found that an MDT approach was instrumental in maintaining low complication rates in cases with extensive DIE involving the intestinal and/or urinary tract. In some cases, where the urologist or the general surgeon were not experienced in laparoscopic surgery, their role was to observe and advise while the procedure was undertaken by the gynaecology team with the agreement that if at any stage and for whatever reason, they felt they needed to intervene, a laparotomy would be performed. We found this mutual understanding and collaboration very useful and to the best interest of the patient.

In addition, we found that routinely videotaping our procedures provided an excellent opportunity for shared learning and reflection. This practice also helped ensuring that occasional missing intraoperative data on the contemporaneous database could be completed later for the purpose of this study. Finally, our study demonstrates the feasibility of setting up a successful tertiary referral center for management of severe endometriosis in the setting of a developing country, implementing international standards and guidance from health authorities.

In conclusion, our study demonstrates that a combination of nodule shaving and bowel resection laparoscopic techniques for the complete excision of all visible DIE within a tertiary referral center results in low complication rates. Our center has a unique set up: a unit in a country with a developing economy, under the strain of long-standing sanctions and their inevitable negative impact. Notwithstanding these obstacles, ACEMIG functions according to international recommendations for endometriosis centers and the unit's multi-disciplinary approach to DIE was essential in the accurate diagnosis and safe treatment of these patients.

Author contribution SK: Project development, Lead surgeon, Manuscript writing and editing, Data analysis. AG: Surgeon, Manuscript writing, Data collection, management and analysis. AM: Database design, project coordination, Data analysis. RK: Surgeon, Data collection. RP: Surgeon, Data collection. KS: Surgeon, Data collection. VM: Data analysis, Manuscript writing and editing

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to declare.

Ethical approval All procedures performed were in accordance with the ethical standards of the Ethics Committee of the Avicenna Research Institute, affiliated to the Academic Center for Education, Culture and Research (ACECR) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards (Ethical Committee approval number IR.ACECR.Avicenna.REC.1395.1).

Informed consent Informed consent was obtained from all patients included in the study. No minors were included in this study.

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