ELSEVIER

JMIG The Journal of Minimally Invasive Gynecology

Review Article

Role of Ovarian Suspension in Preventing Postsurgical Ovarian Adhesions in Patients with Stage III-IV Pelvic Endometriosis: A Systematic Review

Pierluigi Giampaolino, MD, PhD, Luigi Della Corte, MD, Gabriele Saccone, MD, Amerigo Vitagliano, MD, Giuseppe Bifulco, MD, PhD, Gloria Calagna, MD, Jose Carugno, MD, and Attilio Di Spiezio Sardo, MD, PhD

From the From the Departments of Public Health (Drs Giampaolino and Di Spiezio Sardo) and Neuroscience and Reproductive and Odontostomatological Sciences (Drs Della Corte, Saccone, and Bifulco), School of Medicine, University of Naples Federico II, Naples, Italy, Department of Woman's and Child's Health, University of Padua, Padua, Italy (Dr Vitagliano), Department of Obstetrics and Gynecology, "Villa Sofia Cervello" University of Palermo, Palermo, Italy (Dr Calagna), and UHealth Obstetrics & Gynecology, Miller School of Medicine, University of Miami, Miami, Florida (Dr Carugno)

ABSTRACT Endometriosis is a benign complex gynecologic condition with high morbidity that affects women of reproductive age. Pelvic adhesion formation represents a serious clinical challenge in the management of patients with endometriosis. Several interventions aimed at reducing postoperative ovarian adhesion formation have been proposed in recent years. Here we summarize the published evidence on the efficacy of ovarian suspension in preventing postoperative ovarian adhesion formation in women undergoing laparoscopic surgery for stage III-IV endometriosis. The research was conducted using electronic databases. A review of the abstracts of all references retrieved from the search was conducted. Selection criteria for the systematic review included all randomized controlled trials (RCTs) and nonrandomized studies (NRSs) of premenopausal women diagnosed with stage III-IV pelvic endometriosis who underwent ovarian suspension or no ovarian suspension (control group). The RCTs were eligible for meta-analysis. Eight studies, 2 RCTs and 6 NRSs, were included in the systematic review. In all 8 studies, ovarian suspension was performed during surgery for stage III-IV endometriosis. The site of the suspension was the anterior abdominal wall in 76.8% of the cases. Five studies reported the use of polypropylene as suture for the suspension. Removal of the suspension suture in the postoperative period was reported in 6 studies. Pooled data from a meta-analysis of the RCTs show that women who underwent ovarian suspension had a significantly lower incidence of postoperative adhesion formation, particularly of moderate to severe adhesions. Ovarian suspension may reduce the rate and severity of postoperative adhesions formation in women undergoing laparoscopy for the treatment of stage III-IV endometriosis; however, RCTs with larger sample sizes are needed. Journal of Minimally Invasive Gynecology (2019) 26, 53–62

Keywords: Endometriosis; Minimally invasive gynecologic surgery; Ovarian suspension Postoperative ovarian adhesions

Endometriosis is a chronic disease characterized by the growth of endometrial-like glands and stroma outside the uterine cavity [1,2]. It affects up to 10% of women of reproductive age, with a higher prevalence in women with dysmenorrhea (40%–60%), subfertility (21%–47%), or pelvic pain (71%–87%) [1–6]. The American Society for Reproductive Medicine classifies endometriosis as stage I (minimal), II (mild), III (moderate), or IV (severe) based on the type (i.e., number, location, and depth) of implants and on the presence of filmy or dense adhesions. In particular, stage III endometriosis is characterized by numerous deep infiltrating implants, small endometriomas on one or both ovaries, and some filmy adhesions, whereas stage IV endometriosis is characterized by numerous deep infiltrating implants, large endometriomas on one or both ovaries, and numerous dense adhesions [3,7].

Laparoscopic excision of endometriotic lesions and lysis of adhesions is the recognized gold standard treatment for endometriosis [8], obtaining pain reduction and improving the quality of life in 70% to 80% of patients [9]. Nevertheless, the disease and symptoms frequently

The authors declare that they have no conflicts of interest.

Corresponding author: Attilio Di Spiezio Sardo, MD, Department of Public Health, School of Medicine, University of Naples Federico II, Naples, Italy.
E-mail: attiliodispiezio@libero.it

Submitted July 5, 2018, Accepted for publication July 30, 2018.
Available at www.sciencedirect.com and www.jmig.org

1553-4650/$ — see front matter
https://doi.org/10.1016/j.jmig.2018.07.021

recur within 2 to 5 years after surgery [10]. Moreover, a high rate of postoperative adhesion formation has been reported, especially in patients with stage III-IV endometriosis, with a prevalence of 50% to 100% at second-look laparoscopy [11−14]. Postoperative adhesions typically involve the ovaries and the pouch of Douglas [15], causing chronic pelvic pain, dyspareunia, intestinal obstruction, and infertility [11].

Several interventions for reducing the formation of postoperative ovarian adhesions have been proposed [16,17], including temporary ovarian suspension to the abdominal wall [18]. This procedure was first performed in 1970 during abdominal laparotomic surgery to protect the ovaries from irradiation in a woman undergoing radiotherapy for Hodgkin disease [19], and since then has been used to protect the ovaries from pelvic irradiation when necessary [20]. More recently, with increasing experience and refinement of the techniques, ovarian suspension also has been performed to prevent ovarian adhesion formation in the surgical treatment of severe endometriosis [21,22].

Despite the publication of studies evaluating the role of ovarian suspension for the prevention of ovarian adhesions after laparoscopic surgery for endometriosis, the data on this topic have yet to be summarized. Here we aimed to summarize the current evidence on the effectiveness and risks of ovarian suspension for the prevention of postoperative adhesion formation in the surgical management of women with stage III-IV endometriosis.

Methods

Search Strategy

The research was conducted using the following electronic databases: Ovid MEDLINE, Embase, Web of Science, Scopus, ClinicalTrials.gov, and Cochrane Library. The studies were identified using combinations of the search terms "endometriosis," "laparoscopy," "ovarian suspension," "ovariopexy," and "adhesions" from the inception of each database to September 2017. We included all published randomized controlled trials (RCTs) and nonrandomized studies (NRSs).

Study Selection

Selection criteria included RCTs and NRSs (e.g., observational prospective, retrospective cohort studies, case-control studies, case series) on premenopausal women diagnosed with stage III-IV endometriosis (confirmed at the time of surgery) evaluating the impact of ovarian suspension on postoperative adhesion formation. Two surgical procedures were evaluated: transient ovariopexy to the anterolateral abdominal wall and permanent ovariopexy to the ipsilateral round ligament with a resorbable suture. Studies that included patients undergoing unilateral/bilateral oophorectomy and/or hysterectomy were excluded from the analysis.

Data Extraction and Risk of Bias Assessment

All review stages were conducted independently by 2 reviewers, P.G. and L.D.C., who assessed the electronic search, study eligibility, inclusion criteria, risk of bias, data extraction, and data analysis. Disagreements were resolved by discussion with a third reviewer (G.B.).

The risk of bias in each trial included in the meta-analysis was assessed using the criteria outlined in the *Cochrane Handbook for Systematic Reviews of Interventions* [23]. Seven domains related to the risk of bias were assessed in each included trial, because of evidence linking them with biased estimates of treatment effect: random sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other bias. The reviewers' judgments were categorized as "low risk," "high risk" or "unclear risk" of bias. The review was reported following the Preferred Reporting Item for Systematic Reviews and Meta-Analyses (PRISMA) statement [24].

Data Analysis

A meta-analysis was planned only for the RCTs, whereas only a descriptive analysis was performed for the NRSs. The data analysis was completed using RevMan 5.3 (Cochrane Collaboration, London, UK). Between-study heterogeneity was explored using the I^2 statistic, which represents the percentage of between-study variation due to heterogeneity rather than to chance. An I^2 value of 0% indicates no observed heterogeneity, whereas I^2 values $\geq$50% indicate a substantial level of heterogeneity.

The summary measures are reported as summary relative risk (RR) with 95% confidence interval (CI) using the random effects model of DerSimonian and Laird. Potential publication biases were assessed statistically using the Begg and Egger tests. A p value <0.05 was considered statistically significant.

Tests for publication bias were not carried out if the total number of publications included for each outcome was <10. In that case, the power of the tests was too low to distinguish chance from real asymmetry. All analyses were done using an intention-to-treat approach, evaluating women according to the treatment group to which they were randomly allocated in the original trials.

The primary outcome included the prevalence and the severity of ovarian adhesions after ovarian suspension, defined as the total number of adhesions affecting the ovaries and evaluated by means of transvaginal ultrasound (TVU) [16,22,24−26], laparoscopy (LPS) [22,27,28], or transvaginal hydrolaparoscopy (TV-H-LPS) [29]. The severity of ovarian adhesions was graded using the Operative Laparoscopy Study Group (OLSG) criteria (0, no adhesion; 1, smooth and avascular; 2, dense or vascular; 3, cohesive) and the revised American Fertility Society scoring system.

Secondary outcomes included the evaluation of postoperative complications and postoperative pelvic pain

assessed by a visual analog scale (VAS) score. The VAS classified no pain as 0 and the worst imaginable pain as 10. A pain score of 1 to 3 was considered mild; 4 to 7, moderate; and 8 to 10, severe.

Data from each eligible study were extracted without modification of original data and transferred onto a custom-made data collection form. Relevant data not present in the original publications were requested from all the principal investigators.

Results

Study Selection and Study Characteristics

Among the 24 articles identified initially, 8 were included in our systematic review (Fig. 1). These 8 studies included 2 RCTs [16,28],1 pilot RCT [15], and 5 NRSs [17,22,26,27,29] (Table 1). The NRSs included 4 retrospective studies [17,22,26,27] and 1 prospective cohort study [29]. A total of 795 patients were examined in the 8 studies. In all described cases, ovarian suspension was performed in patients diagnosed with stage III-IV endometriosis.

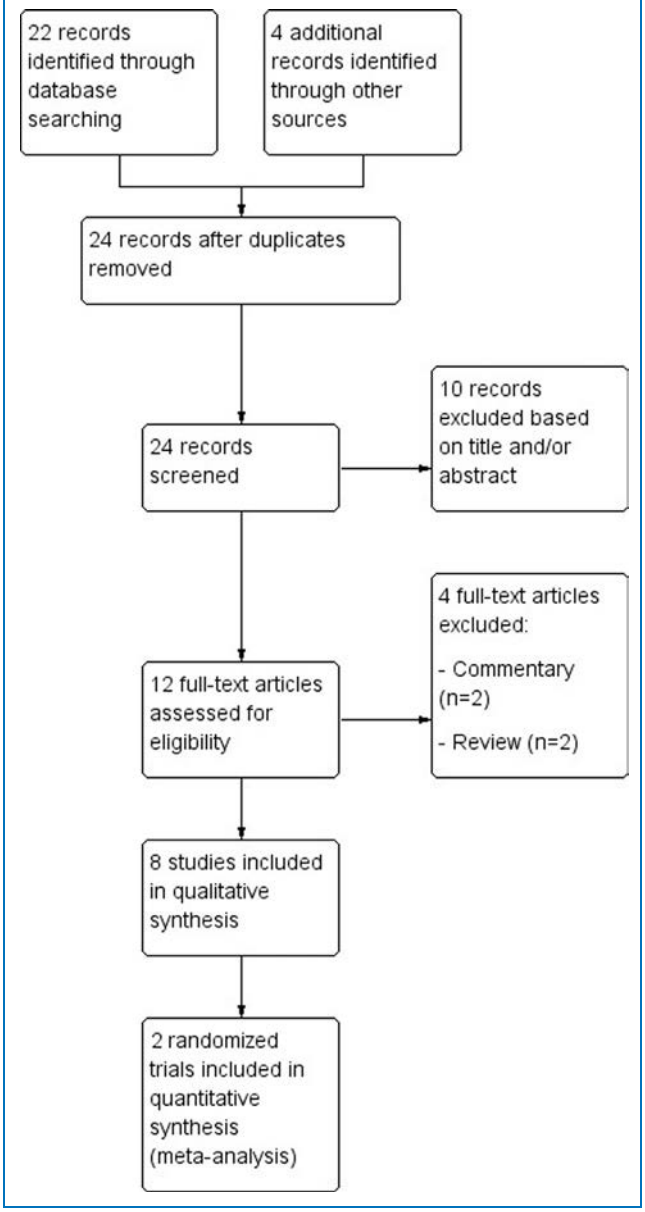
The site of the suspension was the anterior abdominal wall in 610 of the 795 cases (76.8%) [17,22,25−28] and the ipsilateral round ligament in the remaining 185 cases (23.2%) [28]. Five studies, with a total of 502 patients, reported the use of polypropylene (Prolene; Ethicon, Somerville, NJ) as suture material for the suspension [17,25−27]. Six studies reported removal of the suspension suture in the postoperative phase, with various times of removal [17,22,25−27] (Table 1).

In the majority of the included studies, the ovarian suspension was temporary, commonly for a period of 36 to 48 hours, with a transient ovarian suspension of 36 to 120 hours. In 2 studies, ovarian suspension was permanent (Table 1).

All studies reported data on the postoperative evaluation of pelvic adhesion formation (Table 2). As described above, postoperative adhesions were evaluated by TVU [16,25,26,28], LPS [17,27], TVU plus LPS [22], and TV-H-LPS [29]. Three studies reported the evaluation of postoperative pain [16,28,29], and 3 studies reported data on postprocedure pregnancy rate [17,22,27].

Fig. 1

PRISMA flow diagram of studies identified in this systematic review.



Ovarian Suspension Technique

The technique used to perform the ovarian suspension to the abdominal wall was similar in all studies [16,17,22,25,27−29] except that of Pellicano et al [29]. All procedures were performed laparoscopically [16,22,25−28], excluding those performed by Carbonnel et al [17], who used both laparoscopy and laparotomy to carry out the ovarian suspension. Although a different type of suture was used by those authors (see Discussion), a one-stitch simple technique was performed after ovarian cystectomy. In this technique, the needle was introduced into the peritoneal cavity through the lower anterior abdominal wall and was recovered intracorporeally, grasping the end of the thread with a hemostat clamp. The needle was then passed through the ovarian medial side and then out of the abdomen through the abdominal wall near the introduction point. The ovary was temporally suspended to the peritoneum of the lower anterolateral abdominal wall next to the ipsilateral round ligament of the uterus. Approximately 2 to 3 cm was left between the ovary and the pelvic sidewall to avoid fixation and adhesion formation between the 2 structures. One knot was performed extracorporeally and was gradually tied, transiently approximating the medial ovarian side to the anterior pelvic wall. The stitch was removed between 1 and 7 days after the procedure.

Table 1

Characteristics of the studies included in this review

Characteristic	Study							
	Abuzeid et al, 2002 [22]	Ouahba et al, 2004 [26]	Carbonnel et al, 2011 [17]	Hoo et al, 2011 [25]	Poncelet et al, 2012 [27]	Hoo et al, 2014 [16]	Pellicano et al, 2014 [28]	Seracchioli et al, 2014 [29]
Number of patients (type of study)	20 (RS)	20 (RS)	218 (RS)	16 (pilot RCT)	193 (RS)	55 (RCT)	185 (PCS)	88 (RCT)
Mean patient age, yr	32	31.5	32.4	34.6	32.4	32.6	26.5	33.2
Site of suspension	Anterior abdominal wall	Anterior abdominal wall	Anterior abdominal wall	Anterior abdominal wall	Anterior abdominal wall	Anterior abdominal wall	Round ipsilateral ligament	Anterolateral abdominal wall
Surgery type	LPS	LPS	LPS, 193; laparotomy, 25	LPS	LPS	LPS	LPS	LPS
Indication	Endometriosis stage III-IV	Endometriosis stage III-IV	Endometriosis stage III-IV	Endometriosis stage III-IV	Endometriosis stage III-IV	Endometriosis stage III-IV	Endometriosis stage II-III	Endometriosis stage III-IV
Suture (measure)	Polypropylene (3.0)	Prolene (3.0)	Prolene (0); Mersuture (0)	Prolene (0)	Prolene (0); Mersuture (0)	Prolene (NA)	Vicryl Rapid (2.0)	Vicryl (2.0)
Postoperative removal (timing of removal)	Yes (day 5/7)	Yes (day 4)	Yes (day 5)	Yes (36-48 h)	Yes (day 5)	Yes (36-48 h)	No	No
Postoperative adhesion evaluation (n)	TVU, LPS (5)	LPS (8)	LPS (24)	TVU (16)	TVU (136)	TVU (52)	TV-H-LPS (50)	TVU (20)

HE = hemoperitoneum; LPS = laparoscopy; NA = not available; OA = ovarian abscess; PCS = prospective cohort study; RCT = randomized controlled trial; RS = retrospective study; TV-H-LPS = transvaginal hydrolaparoscopy; TVU = transvaginal ultrasound.

Table 2

Outcomes of the studies included in this review

Outcome	Study							
	Abuzeid et al, 2002 [22]	Ouahba et al, 2004 [26]	Carbonnel et al, 2011 [17]	Hoo et al, 2011 [25]	Poncelet et al, 2012 [27]	Hoo et al, 2014 [16]	Pellicano et al, 2014 [28]	Seracchioli et al, 2014 [29]
Timing of postoperative adhesion evaluation	NA	5 mo postsurgery	12 mo postsurgery (mean)	3 mo postsurgery	NA	3 mo postsurgery	2-3 mo postsurgery	6 mo postsurgery
Postoperative ovarian adhesion formation, n/N (%)	2/10 (20)	7/12 (58.3)	19/38 (50)	18/32 (56.3)	NA	20/52 (38.5) vs 27/52 (51.9)	22/54 (40.7)	30/45 (66.7) vs 38/45 (84.4)
Severity of postoperative ovarian adhesions, n/N (%)	NA	4/12 (33.3)	NA	NA	NA	5/52 (9.6) vs 10/52 (19.2)	NA	17/45 (37.8) vs 34/45 (75.5)
Evaluation of postoperative pain (VAS score)	NA	NA	NA	NA	NA	Yes	Yes	Yes
Pregnancy, n/N (%)	8/20 (40)	8/15 (53.3)	58/105 (55)	NA	NA	NA	NA	NA
Immediate postoperative complications, n	None	NA	OA (1); HE (1)	None	OA (1); HE (1)	NA	None	Fever (2); blood loss (1)

HE = hemoperitoneum; NA = not available; OA = ovarian abscess.

In the case of ovarian suspension to the ipsilateral round ligament, the technique was similar to that described above but with the suture carried out approximately 1 cm from the inguinal canal to separate the ovary 1.5 to 2 cm from the ovarian fossa. In this case, the surgeon performed a single running suture using an absorbable monofilament (Vicryl Rapid 2.0, CT-1 needle; Ethicon) and tied with intracorporeal knots (Fig. 2).

Type of Suture

In 6 of the 8 studies, the authors used a synthetic nonabsorbable polypropylene monofilament (0 Prolene; Ethicon) or a braided nonabsorbable polyester suture (0 Mersuture; Ethicon) [16,17,22,25–27]. In the other 2 studies, a single running suture was performed with an absorbable monofilament (Vicryl Rapid 2.0, CT-1 needle; Ethicon) [28,29]. This choice was made to separate the ovary from the injured peritoneal surfaces during the healing process, which often exceeds 7 days, avoiding the development of adhesions within the first 5 to 7 days after surgery. Moreover, Vicryl Rapid 2.0 suture loses tensile strength in 5 to 7 days and is rapidly reabsorbed.

Assessment of Postoperative Adhesions

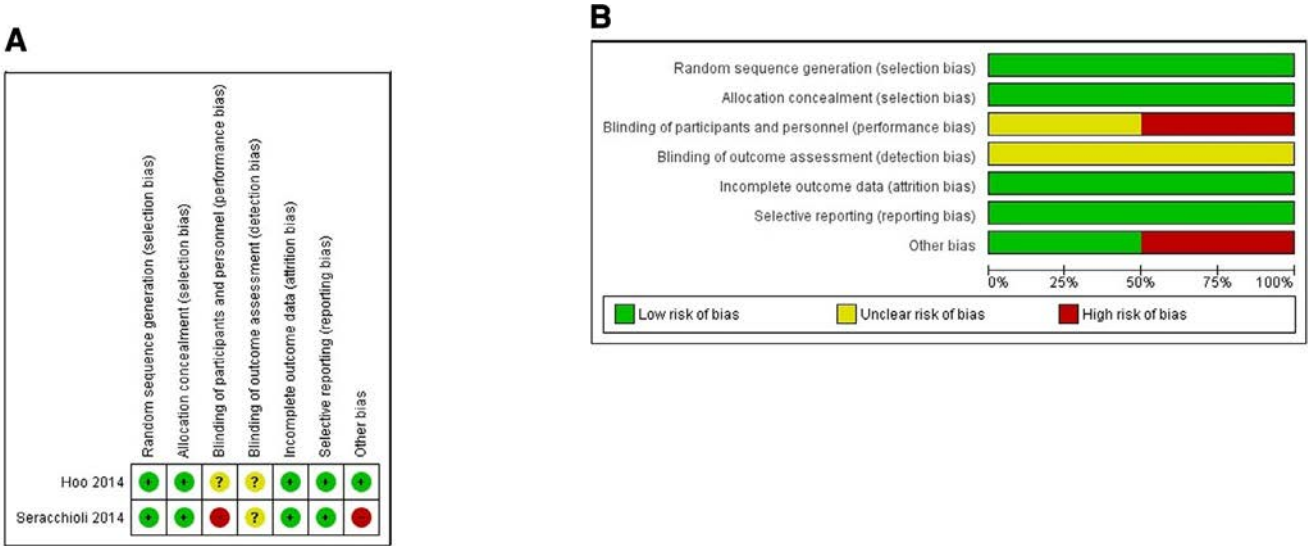
Various methods to determine the presence and location of postoperative pelvic adhesions were different: TVU [16,25,26,28], LPS [17,27], TVU plus LPS [22], and TV-H-LPS [29]. The presence of adhesions evaluated by TVU were classified as minimal, moderate, or severe using the following criteria: adhesions were considered minimal when gentle pressure was not able to separate some (one-third) of the surrounding structures from the ovary but the ovary could be mobilized from the majority (two-thirds) of the surrounding structures; as moderate when one-third to

Fig. 2

Ovarian suspension to the ipsilateral round ligament.

Fig. 3

Assessment of risk of bias. (A) Summary of risk of bias for each trial. +, low risk of bias; -, high risk of bias; ?, unclear risk of bias. (B) Risk of bias graph including each risk of bias item presented as a percentage across all included studies.



two-thirds of ovarian mobility was reduced due to adhesions to the surrounding structures; and as severe when fixed ovaries could not be mobilized with gentle pressure or separated from many of the surrounding structures. Evaluation with LPS and TV-H-LPS was conducted taking into account the presence of filmy, dense, and/or vascular adhesions between the ovaries and nearby organs and/or the pelvic sidewall. The timing of evaluation ranged between 2 and 12 months after surgery. Data on pelvic adhesion formation are reported in Table 2.

Quantitative Analysis

Two RCTs, with a total of 135 patients, were included in the meta-analysis [16,28]. The overall risk of bias was low in these trials (Fig. 3). Both studies had a low risk of bias in "random sequence generation," "incomplete outcome data," and "selective reporting." Adequate methods for allocation of participants were used. Given the intervention, none of the included trials was double-blinded. All randomized women were included in an intention-to-treat analysis. Publication bias, assessed using the Begg and Egger tests, was not significant (p = .69 and .78, respectively).

Pooled data showed that women who underwent ovarian suspension had a significantly lower incidence of overall postoperative adhesions (RR, 0.78; 95% CI, 0.63−0.96; Fig. 4) and of moderate to severe postoperative adhesions (RR, 0.50; 95% CI, 0.34−0.73; Fig. 5).

Qualitative Analysis

The 6 NRSs analyzed included 636 women [17,22,26,27,29], and the pilot RCT included 16 women [25]. Data on the incidence of postoperative ovarian adhesions after ovariopexy are conflicting. Although 2 studies [25,27] reported adhesion formation reductions of <50% (41.7% and 43.7% respectively), Ouahba et al [26] found a significant reduction in the severity of postoperative ovarian adhesions, with the

Fig. 4

Forest plot of the risk of postoperative adhesions.

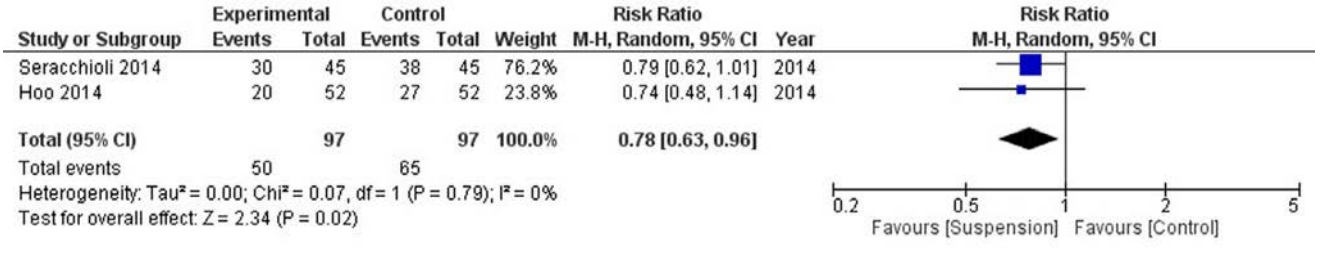
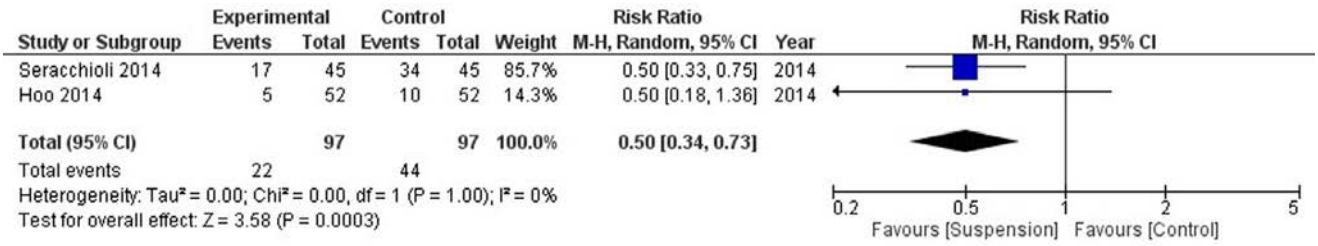


Fig. 5

Forest plot of the risk of moderate to severe adhesions.



presence of organized dense and vascular adhesions between the ovary and the pelvic sidewall in only 4 of 12 ovaries (33.3%), with 5 ovaries adhesion-free and 3 ovaries with only filmy adhesions to the ipsilateral tube. Carbonnel et al [17] reported a reduction of 50% (19 of 38 ovaries free of adhesions), whereas both Abuzeid et al [22] and Pellicano et al [29] reported significantly reduced rates of postoperative ovarian adhesion formation, 20% (2 of 10) and 40.7% (22 of 54), respectively.

Postoperative Complications

Regarding postoperative complications, 3 studies reported an absence of adverse events [22,25,29]. Only 3 studies [17,26,28] reported immediate postoperative complications, in a total of 6 patients, including 2 with fever, 2 with ovarian abscess, and 2 with hemoperitoneum, occurring within several days after surgery. Serrachioli et al [28] reported postoperative fever due to urinary tract infection in 2 patients in their ovarian suspension group and 3 in their control group; 3 patients (1 in the ovarian suspension group and 2 in the control group) experienced significant intraoperative blood loss that resulted in a postoperative hemoglobin <10 g/dL, but none required blood transfusion. Carbonnel et al [17] reported 2 immediate ovarian complications in 297 patients (0.7%) and Poncelet et al [27] reported 2 immediate ovarian complications in 336 patients (0.6%), including 1 ovarian abscess (caused by *Klebsiella pneumoniae*) and 1 hemoperitoneum. These complications may be considered major complications; indeed, in both cases, the abscess was drained by a posterior colpotomy at the time of diagnosis, and a second LPS was required on postoperative day 1 to resolve the hemoperitoneum.

Postoperative Pain

In the studies that evaluated preoperative and postoperative pain, neither Seracchioli et al [28] nor Pellicano et al [29] observed any differences in postoperative pelvic pain between the patient and control groups, as measured by the VAS scale, whereas Hoo et al [16] found a significant improvement in patient pain scores after surgery despite the relatively high prevalence of postoperative pelvic adhesions. Hoo et al [16] also reported a lower mean postoperative VAS score compared with the preoperative score (5.79 vs 1.98), and surmised that postoperative pelvic adhesions likely contribute to the persistent pelvic pain following LPS for endometriosis, along with other, unknown factors. Although the reason for improved pain symptoms irrespective of ovarian suspension is unclear, Seracchioli et al [28] reported that ovarian suspension seems to reduce pain induced by the pressure of vaginal probe, and Hammoud et al [30] considered ovarian adhesions as a cause of pain due to distortion of normal anatomic relationships and stretching of the peritoneum/organ serosa at the adhesion attachment sites.

Pregnancy Rate

Fertility and pregnancy rate after ovarian suspension were evaluated in 3 studies. Ouhaba et al [26] reported that 53.3% of patients who underwent ovarian suspension conceived at an average of 11.5 months after the surgical procedure (range, 4−24 months). Carbonnel et al [17] reported similar results (55%), with a median time to conception of 8.6 ± 1 months: 36% of patients conceived spontaneously, whereas 64% required assisted reproductive technology (ART) [17]. In the 3 studies analyzed, approximately one-half of the women undergoing ovarian suspension were able to conceive after the procedure [17,22,27].

Discussion

Main Findings

Several strategies for adhesion prevention in patients with stage III-IV endometriosis are described in the literature. We have identified and reviewed studies involving both transient and permanent ovarian suspension. To the best of our knowledge, this is the first systematic review with a meta-analysis on this topic.

Our review revealed scarce data in the current literature about ovarian suspension as an adhesion-prevention

strategy after surgery for endometriosis. We identified only 8 studies addressing this practice, including only 2 RCTs.

This lack of scientific evidence may be explained by the fact that the use of ovarian suspension for the prevention of ovarian adhesion formation in patients with endometriosis is a relatively recently described procedure in the field of laparoscopic surgery. Accordingly, 6 of the 8 studies analyzed (75%) were initiated in 2011 or later, indicating that the use of ovarian suspension as an adhesion prevention strategy in patients with severe endometriosis is a recent innovation in gynecologic endoscopy, although its practice is progressively increasing.

Several interventions aimed at reducing postoperative pelvic adhesions and their complications have been studied. Medical therapy and surgery are the main treatment options for endometriosis. The most effective treatment for severe pelvic endometriosis is surgical [16], with the laparoscopic approach the best option [31]. New strategies are needed to maximize the impact of the disease, reducing pain and the potential risk of complications caused by postoperative adhesion formation.

Medical therapeutic options include oral contraceptives, progestogens, androgenic agents, and gonadotropin-releasing hormone analogs [3,32]. In an effort to prevent postoperative adhesion formation, the intraperitoneal administration of antiadhesive solutions, such as icodextrin and hyaluronic acid, anti-inflammatory agents, polyunsaturated fatty acids, chemokine inhibitors, and even antiestrogens, has been studied [13]. However, despite the development of many novel antiadhesion agents, surgery appears to be the most effective strategy in preventing adhesion formation [33].

The basic concept of transient "oophoropexy" during surgery for severe endometriosis arises from the goal of keeping the ovary away from the surrounding injured peritoneum during the immediate postsurgical peritoneal healing based on findings of animal studies showing reduced adhesion formation when separation of injured peritoneal surfaces was maintained for at least 36 hours [34]. Oophoropexy may represent a good option to avoid periovarian adhesion formation. The main proposed site of suspension was the abdominal wall, and the timing of postoperative adhesions evaluation ranged from 3 to 12 months after surgery.

Recent improvements in ultrasound technology has allowed for its use as a reliable technique for detecting pelvic adhesions and evaluating their severity. Gentle pressure with the vaginal probe and an abdominal compression with the examiner's free hand have been used to assess the presence of ovarian adhesions. The presence of adhesions is diagnosed when it is impossible to separate the ovary from the peritoneum of the pelvic sidewall and/or pouch of Douglas. Currently, LPS remains the gold standard for the diagnosis and staging of deep infiltrating endometriosis (DIE) [35]. The surgical treatment of these lesions represents a challenge for surgeons owing to the high rate of intraoperative/postoperative complications. Although laparoscopy allows for direct access to the lesions, an accurate preoperative assessment of DIE implant location and extension is crucial; for these reasons, new modified standard TVU techniques, which differ from standard ultrasonography by the introduction of a contrast medium into the vagina or rectum, are under evaluation [35,36].

The OLSG scoring system has been used to quantify the results after oophoropexy in 2 studies. In the studies reported by Carbonnel et al [17] and Hoo et al [27], 50% of suspended ovaries had absent or only thin adhesions on second-look LPS. Pellicano et al [29] found a significant difference between patients undergoing ovarian suspension to the ipsilateral round ligament and patients without additional procedures. In their study, 66.7% of patients in the ovarian suspension group had no postoperative ovarian adhesions, compared with only 19.2% of those in the control group [29]. Only 1 study reported outpatient TV-H-LPS for assessing postoperative ovarian adhesions at 60 to 90 days after surgery [29], whereas in all other studies, the evaluation of adhesion formation was done with ultrasound or second-look LPS [17,22,25–29]. Serrachioli et al [28] classified ovarian adhesions diagnosed by TVU as mild, moderate, or severe, finding increased ovarian mobility from the surrounding structures, such as uterus and bowel; reduced postoperative severe adhesions; and diminished ovarian pain under the pressure of the vaginal probe in the ovarian suspension group. Moreover, all the studies that assessed adhesions on second-look LPS found an absence of adhesions in 40% to 80% of patients.

The most commonly used suture material was synthetic, nonabsorbable, polypropylene monofilament (0 Prolene; Ethicon), and a braided, nonabsorbable polyester suture (0 Mersuture; Ethicon). Some studies used absorbable sutures, avoiding the need for suture removal and perhaps obviating the possibility of infection [25].

All 8 studies found the procedure to be safe and well tolerated, with no major complications and only minor postoperative complications in 3 studies [17,26,28]. Out of 795 patients who underwent ovarian suspension, only 2 cases of ovarian abscess formation caused by *K pneumoniae*, 2 cases of hemoperitoneum, 2 cases of fever (>38° C), and 1 case of excessive intraoperative blood loss resulting in a postoperative hemoglobin level <10 mg/dL occurring several days after surgery were reported [17,26,28] (Table 2). The patients with fever required a 7-day course of antibiotic treatment [28]. The patients diagnosed with ovarian abscess due to *K pneumoniae* had the abscess drained via posterior colpotomy on postoperative day 8, whereas the patients with hemoperitoneum were treated via laparoscopy on the first postoperative day [17,26]. Although these complications occurred after the procedure, it is likely that excessive blood loss, fever and hemoperitoneum were related to the complex laparoscopy per se rather than to the ovarian suspension part of the procedure. The only complication secondary to the ovarian suspension could be the ovarian abscess, demonstrating the safety of this technique.

The intensity of pelvic pain was evaluated using the VAS score preoperatively and 3 to 6 months after the procedure. No difference was reported by Pellicano et al [29] and Seracchioli et al [28], whereas Hoo et al [16] reported improved pain scores after surgery. The correlation between oophoropexy and postoperative pelvic pain is not clear, given that the painful symptoms experienced by patients after laparoscopic procedures are likely multifactorial in nature and may depend on the extent of the surgical procedure. Moreover, the ovary has visceral innervation, which differs from the somatic-type pain commonly reported by patients in the postoperative period [37].

The evaluation of fertility and pregnancy rate after this procedure is difficult to interpret because of the scant available data. Although some studies have reported encouraging results [17,22,27] (Table 2), evaluation of the pregnancy rate should take into account multiple factors, such as the advanced reproductive age of patients, potential male factor infertility, and history of pelvic inflammatory disease in addition to endometriosis, as noted by Abhuzeid et al [22], as well as the use of assisted reproductive technology in women unable to conceive spontaneously.

We acknowledge limitations of this review resulting from the high heterogeneity among the studies, the presence of only 2 RCTs, as well as the different methods used (TVU, LPS, TVU plus LPS, and TV-H-LPS) to evaluate postoperative adhesion formation. Indeed, 4 of the 8 studies, including the only 2 studies in the meta-analysis, used only TVU to evaluate postoperative adhesions [16,25,26,28], whereas 1 study used both TVU and LPS [22]. Moreover, the 2 RCTs differed in terms of suture types and, consequently, ovarian suspension times.

Conclusions

Our data support the use of ovarian suspension as a safe, simple, feasible and effective strategy to reduce the incidence as well as the severity of postoperative ovarian adhesion formation in women undergoing laparoscopic surgery for stage III-IV endometriosis. Oophoropexy represents an option for preventing adhesion formation in the surgical management of patients with stage III-IV endometriosis. Given the scant available scientific evidence, further studies are needed to confirm our findings.

References

1. Granese R, Perino A, Calagna G, et al. Gonadotrophin-releasing hormone analogue or dienogest plus estradiol valerate to prevent pain recurrence after laparoscopic surgery for endometriosis: a multi-center randomized trial. *Acta Obstet Gynecol Scand*. 2015;94:637–645.
2. Morelli M, Sacchinelli A, Venturella R, Mocciaro R, Zullo F. Postoperative administration of dienogest plus estradiol valerate versus levonorgestrel-releasing intrauterine device for prevention of pain relapse and disease recurrence in endometriosis patients. *J Obstet Gynaecol Res*. 2013;39:985–990.
3. Fauconnier A, Chapron C. Endometriosis and pelvic pain: epidemiological evidence of the relationship and implications. *Hum Reprod Update*. 2005;11:595–606.
4. Falcone T, Flyckt R. Clinical management of endometriosis. *Obstet Gynecol*. 2018;131:557–571.
5. Balasch J, Creus M, Fábregues F, et al. Visible and non-visible endometriosis at laparoscopy in fertile and infertile women and in patients with chronic pelvic pain: a prospective study. *Hum Reprod*. 1996;11:387–391.
6. Carter JE. Combined hysteroscopic and laparoscopic findings in patients with chronic pelvic pain. *J Am Assoc Gynecol Laparosc*. 1994;2:43–47.
7. American Society for Reproductive Medicine. Revised American Society for Reproductive Medicine classification of endometriosis: 1996. *Fertil Steril*. 1997;67:817–821.
8. Garry R. Laparoscopic excision of endometriosis: the treatment of choice? *Br J Obstet Gynaecol*. 1997;104:513–515.
9. Muzii L, Marana R, Angioli R, et al. Histologic analysis of specimens from laparoscopic endometrioma excision performed by different surgeons: does the surgeon matter? *Fertil Steril*. 2011;95:2116–2119.
10. 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.
11. diZerega GS. Contemporary adhesion prevention. *Fertil Steril*. 1994;61:219–235.
12. Kavic SM, Kavic SM. Adhesions and adhesiolysis: the role of laparoscopy. *JSLS*. 2002;6:99–109.
13. Redwine DB. Conservative laparoscopic excision of endometriosis by sharp dissection: life table analysis of reoperation and persistent or recurrent disease. *Fertil Steril*. 1991;56:628–634.
14. Canis M, Mage G, Wattiez A, Chapron C, Pouly JL, Bassil S. Second-look laparoscopy after laparoscopic cystectomy of large ovarian endometriomas. *Fertil Steril*. 1992;58:617–619.
15. Diamond MP, Linsky CB, Cunningham T, et al. Adhesion reformation: reduction by the use of Interceed (TC7) plus heparin. *J Gynecol Surg*. 1991;7:1–6.
16. Hoo WL, Stavroulis A, Pateman K, et al. Does ovarian suspension following laparoscopic surgery for endometriosis reduce postoperative adhesions? *An RCT. Hum Reprod*. 2014;29:670–676.
17. Carbonnel M, Ducarme G, Dessapt AL, et al. Efficacy of transient abdominal ovariopexy in patients with severe endometriosis. *Eur J Obstet Gynecol Reprod Biol*. 2011;155:183–187.
18. Abuzeid MI, Ashraf M. Temporary ovarian suspension to prevent postoperative adhesions. *J Minim Invasive Gynecol*. 2001;8:S2.
19. Ray GR, Trueblood HW, Enright LP, Kaplan HS, Nelsen TS. Oophoropexy: a means of preserving ovarian function following pelvic megavoltage radiotherapy for Hodgkin's disease. *Radiology*. 1970;96:175–180.
20. Tulandi T, Al-Took S. Laparoscopic ovarian suspension before irradiation. *Fertil Steril*. 1998;70:381–383.
21. Agarwal N, Subramanian A. Endometriosis: morphology, clinical presentations and molecular pathology. *J Lab Physicians*. 2010;2:1–9.
22. Abuzeid MI, Ashraf M, Shamma FN. Temporary ovarian suspension at laparoscopy for prevention of adhesions. *J Am Assoc Gynecol Laparosc*. 2002;9:98–102.
23. Higgins JPT, Green S, et al. Cochrane handbook for systematic reviews of interventions, version 5.1.0 (updated March 2011). Available at: http://training.cochrane.org/handbook. Accessed September 20, 2017.
24. Moher D, Liberati A, Tetzlaff J, Altman DG. PRISMA Group. Preferred reporting items for systematic review meta-analyses: the PRISMA statement. *Open Med*. 2009;3:e123–e130.
25. Hoo WL, Saridogan E, Cutner A, Pandis G, Jurkovic D. Effectiveness of ovarian suspension in preventing post-operative ovarian adhesions in women with pelvic endometriosis: a randomised controlled trial. *BMC Womens Health*. 2011;11:14.

26. Ouahba J, Madelenat P, Poncelet C. Transient abdominal ovariopexy for adhesion prevention in patients who underwent surgery for severe pelvic endometriosis. *Fertil Steril*. 2004;82:1407–1411.
27. Poncelet C, Ducarme G, Yazbeck C, Madelenat P, Carbonnel M. Safety of transient abdominal ovariopexy in patients with severe endometriosis. *Int J Gynaecol Obstet*. 2012;118:120–122.
28. Seracchioli R, Di Donato N, Bertoldo V, et al. The role of ovarian suspension in endometriosis surgery: a randomized controlled trial. *J Minim Invasive Gynecol*. 2014;21:1029–1035.
29. Pellicano M, Giampaolino P, Tommaselli GA, Catena U, Nappi C, Bifulco G. Efficacy of ovarian suspension to round ligament with a resorbable suture to prevent postoperative adhesions in women with ovarian endometrioma: follow-up by transvaginal hydrolaparoscopy. *Gynecol Surg*. 2014;11:261–266.
30. Hammoud A, Gago LA, Diamond MP. Adhesions in patients with chronic pelvic pain: a role for adhesiolysis? *Fertil Steril*. 2004;82:1483–1491.
31. Royal College of Obstetricians and Gynaecologists. Endometriosis, investigation and management (green-top guideline 24). Available at: http://www.rcog.org.uk/womens-health/clinical-guidance/investigationand-management-endometriosis-green-top-24. Accessed May 21, 2018.
32. Makiyan Z. Endometriosis origin from primordial germ cells. *Organogenesis*. 2017;13:95–102.
33. Metwally M, Cheong Y, Li TC. A review of techniques for adhesion prevention after gynaecological surgery. *Curr Opin Obstet Gynecol*. 2008;20:345–352.
34. Noventa M, Saccardi C, Litta P, et al. Ultrasound techniques in the diagnosis of deep pelvic endometriosis: algorithm based on a systematic review and meta-analysis. *Fertil Steril*. 2015;104:366–383. e2.
35. Saccardi C, Gizzo S, Vitagliano A, et al. Peri-incisional and intraperitoneal ropivacaine administration: a new effective tool in pain control after laparoscopic surgery in gynecology: a randomized controlled clinical trial. *Surg Endosc*. 2016;30:5310–5318.
36. Saccardi C, Cosmi E, Borghero A, Tregnaghi A, Dessole S, Litta P. Comparison between transvaginal sonography, saline contrast sonovaginography and magnetic resonance imaging in the diagnosis of posterior deep infiltrating endometriosis. *Ultrasound Obstet Gynecol*. 2012;40:464–469.
37. Harris ES, Morgan RF, Rodeheaver GT. Analysis of the kinetics of peritoneal adhesion formation in the rat and evaluation of potential antiadhesive agents. *Surgery*. 1995;117:663–669.