A Systematic Review and Meta-Analysis for Surgical Techniques Intended to Alleviate Post-Operative Adhesions Following Abdominal and Pelvic Surgery


ABSTRACT

Background: postoperative peritoneal adhesions are common and frequent complication following abdominal and Pelvic Surgery. Adhesions can lead to bowel obstructions and infertility in women (when they develop around the reproductive organs), chronic pain which consequently results in reducing the quality of life for patients, level of energy, productivity, and increase the risk, complexity and chance of complications in subsequent surgeries. Main objective of this review is to study the implication of using the ‘good surgical techniques’ in the prevention of postoperative adhesions.

Methods: the present review included randomized controlled trials (RCTs) that investigated the different surgical technique impact on adhesion-related outcomes were identified through search in Pubmed, CENTRAL and Embase. Identified endpoints were: clinical outcomes and incidence of adhesions. The primary Identification of papers and data extraction were performed by independent researchers.

Results: out of 1709 studies, there were only 21 papers eligible for a systematic review and included in the meta-analysis and qualitative assessment. None of the techniques that were compared significantly reduced the incidence of adhesive small bowel obstruction. In a small low-quality trial, the pregnancy rate increased after subserous fixation of suture knots. However, the incidence of adhesions was lower after laparoscopic compared with open surgery [relative risk (RR) 0.14; 95% confidence interval (CI): 0.03–0.61] and when the peritoneum was not closed (RR 0.36; 95% CI: 0.21–0.63).

Conclusion: None of the specific techniques that were compared reduced the two main adhesion-related clinical outcomes, small bowel obstruction and infertility. The meta-analysis provides some evidence for the surgical principle that using less invasive techniques, introducing less foreign bodies or causing less ischemia reduces the extent and severity of adhesions.

Keywords: adhesions, bowel obstruction, laparoscopy, pelvic surgery, infertility.

INTRODUCTION

Adhesions are defined as abnormal fibrous connection between 2 anatomically different surfaces.

Adhesions may appear as thin sheets of tissue similar to plastic wrap or as thick fibrous bands. The tissue develops when the body's repair mechanisms respond to any tissue disturbance, such as surgery, infection, trauma, or radiation. Although adhesions can occur anywhere, the most common locations are within the stomach, the pelvis, and the heart (1).

It is estimated that 93% to 100% of patients who undergo transperitoneal surgery will develop postoperative adhesions (5). The extent of adhesion formation varies from one patient to another and is most dependent on the type and magnitude of surgery performed, as well as whether any postoperative complications develop.

Post-operative adhesion has proved to be a scourge after peritoneal injury in abdominal and pelvic surgery. Notable among its potential sequelae are infertility (3) with increased risk of ectopic pregnancy, should the patient subsequently conceive (4), abdominal and pelvic pain (5), bowel obstruction (6), and difficult repeat surgical procedures (7). In addition, abdominopelvic adhesions may interfere with the disbursement of intraperitoneal chemotherapy in patients with abdominal or pelvic cancer (8).

The risk for adhesion-related complication is highest following colorectal surgery and surgery of the ovaries, with a 10-year risk of readmission directly related to adhesions as high as 8.8 and 7.5%, respectively (9). It’s quite difficult to completely eliminate the root causes and factors that contribute to the formation of adhesions such as:

- Trauma: Surgery is trauma, and the body may form adhesions as a defense against that trauma as a normal part of the healing process.
Ischemia: During surgery, the cutting of tissue, clotting of blood or tying of stitches can disrupt blood flow, resulting in ischemia, the reduction of blood flow to the tissues, and therefore contributing to adhesion formation.

Inflammation: Endometriosis and pelvic inflammatory disease can cause inflammation that results in adhesion formation.

Foreign bodies: Stitches, lint from sponges and powder from surgical gloves are among the things that may find their way into the patient’s body and cause inflammatory reactions, triggering adhesion formation.

Strict adherence to meticulous surgical technique has been advocated for many years by surgeons and surgical texts as a means to reduce adhesion formation after transperitoneal surgery. Although such efforts rarely prevent adhesions in most patients, the principle of good surgical technique to decrease peritoneal injury should not be discounted, because such practices can also influence the risk of developing complications associated with surgical procedures.

The measures that have been described and advocated for decreasing adhesion formation include minimizing peritoneal foreign body exposure (e.g., using suture material only as necessary, eliminating glove powder by washing gloved hands before surgery), careful tissue handling, using cautery and retractors sparingly, ensuring meticulous hemostasis while avoiding desiccation and ischemia, administering prophylaxis against infection and avoiding the use of overheated irrigation fluids.

METHODS
The research team searched Pubmed, Embase and CENTRAL from January 1990 to December 2014, using Predefined search terms and keywords in Pubmed and Embase for surgi*, surgie*, intraabdominal, intraperitoneal, abdo*, peritoneal, laparotom*, laparoscopy*, leostom*, pelv*, female infertility, small bowel obstruction, cesarean section for patients, sutur*, peritoneal, peritoneum, closure for intervention and adhesi* & tissue adhesions for the Outcome.

Whenever possible, the strategies were elaborated with the controlled vocabulary subject descriptors of Mesh/Medline and DeCs/BVS. Besides, free text terms searched in the main periodicals, as well as in references, abstracts and comments of related articles were used to increase the sensitivity of the search. The search was combined with Boolean operators “OR” for addition and “AND” for the list of terms. No idiom filters were applied.

Limits
- Subheadings: NOT (animal NOT human)
- Publication date: 1 January 1990 or later

* = truncation; retrieves all possible suffix variations of root word indicated

Moreover, a manual search of the bibliographies of relevant papers was carried out to identify additional studies for possible inclusion.

Study selection
Paper selection was based on title and abstract in the first filtration round, followed by a more comprehensive full text selection, by 3 groups of the research team working independently, against pre-specified criteria.

We included studies that reported on adhesion related complications after peritoneal surgery. We excluded case series with less than 10 patients.

Data extraction
From the relevant articles, we extracted information on study design, characteristics, number of participants, and outcomes reported. The primary outcome of interest was the incidence of adhesive small bowel obstruction during follow-up after peritoneal surgery, which we defined as any episode of postoperative small bowel obstruction with the presence of adhesions confirmed during reoperation or by imaging after exclusion of other causes of bowel obstruction. Secondary outcomes of interest related to small bowel obstruction were incidence of postoperative small bowel obstruction by any cause, the cross sectional incidence of adhesions in all patients with postoperative small bowel obstruction, the number of reoperations for adhesive small bowel obstruction, mortality, and length of hospital stay related to adhesive small bowel obstruction. Secondary outcomes related to complications during reoperation were the incidence of inadvertent enterotomy and the difference in operative time between patients with and without previous surgery. Secondary outcomes related to infertility were the pregnancy rate following surgery, the pregnancy rate compared before and after surgery, use of fertility treatment following surgery, and incidence of adhesions in patients evaluated for infertility after surgery. We excluded surgical studies on operations that directly affected fertility, such as hysterectomy, bilateral ovariectomy, and sterilization. The secondary outcomes related to chronic pain were the incidence of chronic pain...
following surgery and the incidence of adhesions in patients evaluated for chronic pain.

**Data and statistical analysis**

Data extraction and meta-analysis were performed following the recommendations of the Cochrane Handbook and QUOROM statement. Studies designed to assess an adhesion end-point, with low risk of bias on at least three domains, <10% of patients lost to follow-up and no important flaws in design were considered high-quality RCTs. When appropriate, a separate analysis was made for high-quality and low-quality studies in addition to the pooled analysis. The Mantel–Haenszel method was applied for pooling of dichotomous data and presented as relative risk (RR) with 95% confidence interval (CI). The inverse variance method was used for pooling continuous data and this was presented as SMD and 95% CI. A fixed-effects model was applied for meta-analysis.

**RESULTS**

Searches identified 1709 publications in addition to another 17 publications that were found through manual research. After removal of duplicates, abstracts and titles, 1403 publications were assessed. There were 178 potentially relevant papers were identified from title and abstract, and 1203 papers were excluded. 30 papers full text could not be retrieved and another 85 papers with the same cohort. There were also 71 papers excluded because they did not compare different surgical techniques or did not report an adhesion-related outcome. We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines in reporting the results (Fig. 1).

Eventually, 21 papers describing 21 studies were included Laparoscopy versus laparotomy. All of them were published between 1991 and 2010 and addressed different topics of surgical technique (Table 1).

Four topics of surgical technique were studied in more than one study:

1. Closure of the parietal peritoneum
2. Laparoscopy or laparotomy
3. Use of laser during surgery
4. Second look surgery versus no second look surgery
5. Suturing following salpingotomy.

Other topics were the technique used for Caesarean section, the use of sutures in comparison to electrocautery to achieve haemostasis, two suturing techniques in laparoscopic myomectomy, two suturing methods following salpingotomy, the type of incision in the operative treatment of bowel perforation and a variety of techniques for laparoscopic ovarian drilling in patients with polycystic ovarian syndrome. Median sample size was 75 (range: 17–794).

Three papers were published comparing adhesion formation between laparoscopy and laparotomy. Three studies of patients undergoing bowel resection reported on ASBO as secondary end-point and thus were not powered for ASBO. Two trials assessing incidence of ASBO were suitable for meta-analysis (12,13). The incidence of ASBO confirmed by surgery was not significantly different between patients undergoing laparoscopy or laparotomy (RR 0.14; 0.02–1.12; P ¼ 0.06). Ng et al. additionally reported the incidence of clinical suspicion of ASBO, which was lower in patients undergoing laparoscopy (RR 0.14; 95% CI: 0.03 0.61; P ¼ 0.008).

Two trials compared pregnancy rate following laparoscopic or open surgery (11). However the more recent study has been taken into consideration since the results for both were highly heterogeneous (I² 72%). Adhesions at second look were found in 1/39 patients (2.6%) after laparoscopy, compared with 30/37 patients (81.1%) after open gynaecological surgery (RR 0.03; 95% CI: 0.00 –0.22; P , 0.001) in one trial (11).

Two studies analysed the incidence of ASBO retrospectively in cohorts previously randomized between laparoscopic or open colorectal surgery. Taylor et al. found no significant difference in the incidence of ASBO between patients operated laparoscopically or by open surgery (7/280; 2.5% versus 4/131; 3.1%; P ¼ 0.749). In the study of Stocchi et al. 2/27 patients in the laparoscopic group versus 0/29 patients in the open group required reoperation for ASBO (P ¼ 0.23). Again, the study of Lundorff et al. was excluded for meta-analysis on the outcome incidence of adhesions because 27.8% of randomized patients did not return for a second look laparoscopy. In this study, the incidence of adhesions was 18/31 (58.1%) following laparoscopic and 33/42 (78.6%) following open surgery, but this difference was not significant (P¼ 0.08).

**Peritoneal closure**

Seven of the included studies compared adhesion formation after peritoneal closure or non-closure of the peritoneum. Three trials
were eligible for meta-analysis\(^{(14,15,16)}\). One high-quality trial studied the incidence of ASBO following hysterectomy and pelvic node dissection in 120 patients. Only one patient in the non-closure group was reoperated for ASBO, with the adhesive band found at the plane of the pelvic node dissection. The difference was not significant (2.95; 95% CI:0.12 –73.9;P¼ 0.51)\(^{(15)}\). The incidence of adhesions was significantly lower when the peritoneum was left open in one trial (RR 0.36; 95% CI: 0.21 –0.63;P, 0.001\(^{(16)}\). The adhesion score was significantly lower in a high-quality trial in patients with ovarian cancer, when the peritoneum was not closed 9.1+2.8 versus 6.1+2.4; SMD 21.14 (95% CI:21.56,20.72;P, 0.001)\(^{(14)}\).

Three studies investigating adhesion formation after closure or nonclosure of the peritoneum in Caesarean section were excluded from meta-analysis because only a small portion of patients returned for a second operation with evaluation of adhesion formation\(^{(16,27,28)}\). The results from these studies were highly heterogeneous (I\(^2\) 67%) and a mean of 77.1% of patients were lost to follow-up. No conclusions could be drawn from these studies on the incidence of adhesions after closure or non-closure of the peritoneum (RR 1.02; 95% CI: 0.43–2.40;P¼ 0.97).

**Caesarean section**

The study of Nabhan et al. on Caesarean section was separately analysed because the operative technique between the experimental and control group differed on more aspects than peritoneal closure alone. This study was not suitable for meta-analysis because 79.3% of patients were lost to follow-up\(^{(29)}\). In the standard technique control group, Caesarean section was performed using the traditional Pfannenstiel –Kerr technique, making a bladder flap and closing the peritoneum. In the modified technique group, the Joel –Cohen –Stark technique (based on the Misgav Ladach technique) was used without making a bladder flap and without closing the peritoneum. The incidence of adhesions was significantly lower in the modified technique group (11.3 versus 35.5%;P¼ 0.003)\(^{(29)}\). Obviously, this reduction cannot solely be attributed to peritoneal non-closure.

**Haemostasis**

Pellicano et al. randomized 32 women undergoing surgery for ovarian endometrioma. Haemostasis was achieved by intra-ovarian suturing with only light additional coagulation if necessary or by using bipolar coagulation only. The adhesion score, expressed by the American Society for Reproductive Medicine score, was significantly lower in the suturing group at a second look, 5.4+2.1 versus 10.3+2.9 (SMD 21.87; 95% CI: 22.79, 20.94; P, 0.001). The incidence of adhesions was not significantly different (RR 0.54; 95% CI: 0.21–1.37; P¼ 0.19)\(^{(23)}\).

**Second-look fertility surgery**

Two trials in fertility surgery compared pregnancy rates between patient undergoing single-stage fertility surgery and patients who had a second-look laparoscopy\(^{(18)}\). There were 129 patients randomized and there was no loss to follow-up. The pregnancy rate was 22/65 (33.8%) in patients with a second-look surgery compared with 30/64 (46.9%) after single stage surgery (RR 0.73; 95% CI: 0.48 –1.11; P¼ 0.14). In the trial of Alborzi et al. the number of live births was 11/46 (23.9%) in the second-look group, compared with 15/44 (34.1%) in the single stage surgery group (RR 0.55; 95% CI: 0.30 –1.03; P¼ 0.06).

**Suturing in salpingotomy**

Two studies analysing pregnancy rates after suturing or no suturing following salpingotomy were included in the qualitative assessment. Fujishita et al. analysed the pregnancy rate in 32 patients with a pregnancy desire. In the group without suturing, 15/19 (78.9%) conceived, compared with 12/13 (92.3%) in the group with suturing after the salpingotomy. The difference was not significant (P¼ 0.27)\(^{(31)}\). The number of live births was not reported. Tulandi and Guralnik reported the intrauterine pregnancy rate after randomizing 34 patients to salpingotomy with or without suturing. The reported 2-year pregnancy rate was 45% in the nonsuturing group and 47% in the suturing group.

**Laparoscopic ovarian drilling**

Three trials addressed distinct aspects of laparoscopic ovarian drilling in patients with polycystic ovarian syndrome. The clinical pregnancy rate was comparable in one study randomizing 44 patients between unilateral and bilateral treatment (RR 1.00; 0.52, 1.91; P¼ 1.00); in both groups 10/22 patients became pregnant. The number of live births was 8/22 in the unilateral group and 9/22 in the bilateral group (RR 0.89; 95% CI: 0.42–1.88; P¼ 0.74)\(^{(39,21)}\), studied the pregnancy rate following laparoscopic ovarian drilling after randomizing between bipolar or unipolar electrocautery in 20 patients. In the bipolar group 7/10 (70%)...
patients Figure 2 Summary of meta-analysis presenting relative ratio with CI for primary outcomes per comparison of techniques. The number of live births was four in the unipolar group and was not reported for the bipolar group, thus comparison was not possible. randomized the right and left ovaries to 6 or 12 puncture holes in 90 women undergoing bilateral ovarian drilling using a unipolar electrocautery technique. The site-specific incidence of adhesions was 41/90 or 42/90, respectively, after 6 or 12 punctures (RR 0.98; 95% CI: 0.71 –1.34; P ¼ 0.88) (20).

Miscellaneous

Two techniques of suturing weew compared in patient undergoing laparoscopic myomection. Subserous suturing was done with a first deep uterine crossing of the suture and a second subserous trans- fixation of the knot. This was compared with deep figure of eight suturing as the standard treatment. Both suturing methods where tested among two groups, one with and one without additional use of an anti-adhesive hyaluronic acid gel. A trend towards a higher pregnancy rate was demonstrated for the subserous sutures in both the anti-adhesive gel group and the group without adhesion barrier. Clinical pregnancy rate was significantly higher when comparing subserous sutures (14/18; 77.8%) to standard sutures (7/18; 38.9%) when analysing the adhesion barrier and non-barrier groups together (RR 2.56; 95% CI: 1.11, 5.87; P ¼ 0.03). The number of live births was not reported. The incidence of ASBO in 56 patients with small bowel perforation in enteric fever was analyzed , comparing a right paramedian incision to a Rutherford –Morrison incision. The Rutherford – Morrison incision is a right iliac incision similar to the muscle splitting incision used for appendectomy except that all muscle fibres are cut in the same line. In both groups, one patient required reoperation for ASBO (RR 1.07; 95% CI: 0.7 –16.33; P ¼ 0.96) . Clinically suspected ASBO could not be analysed because of the methods of follow-up and criteria for clinical diagnosis of ASBO were not reported.

The present study results concorded with a meta-analysis study done by R.P.G. ten Broek et al. (11)

DISCUSSION

This study is intended to shed some light on the different surgery techniques that can help alleviate abdominal adhesions provided the fact that they are mostly induced by abdominal surgery. Adhesions can become larger and tighter as time passes, causing potential serious issues years after surgery. Surgery-induced causes of abdominal adhesions include: tissue incisions, especially those involving internal organs, the handling of internal organs, the drying out of internal organs and tissues, contact of internal tissues with foreign materials, such as gauze, surgical gloves, and stitches and blood or blood clots that were not rinsed out during surgery. Almost everyone who undergoes abdominal surgery develops adhesions; however, the risk is greater after operations on the lower abdomen and pelvis, including bowel and gynecological surgeries. None of the different techniques or approaches evidently showed a reduction of the main adhesion related complications ASBO and infertility. The incidence of ASBO, established by reoperation, was not significantly different in any comparison.

• Clinical suspicion of ASBO: lower following laparoscopy compared with open surgery in one study.
• The incidence of adhesions was lower following:
  a. laparoscopy than laparotomy
  b. Peritoneum closure versus leaving it open.
• Evidence for a lower incidence of adhesions was limited to a single small RCT and conflicting results were found in the qualitative assessment of lower quality studies.
• Pregnancy rate: significantly higher in one study after subserous fixation of sutures compared with standard sutures in a small low-quality RCT.

Limitation of the study

1- Papers before 1990 we excluded (in order to minimize bias ); since sensitivity analyses did not show relevant differences between the period before and after 2000 and hence , we could combine the data from the studies of the past two decades to provide a more precise estimate. In addition to that, studies done before 1990 would not provide an estimate that is generalizable to current practice because of the broad introduction of laparoscopy in general surgery at that time and the increased use of tissue sparing techniques and instruments at the end of the 20th century.

2- About 17% of papers could not be retrieved.

3- There was evidence of considerable heterogeneity. Local variations in operative techniques, environmental factors, and the
case mix seem to influence the incidence of adhesion related complication
4- We did not report costs and quality of life implications as these were either not reported at all or reported in such a heterogeneous way that pooling was not possible.

Implications for clinical practice
None of the different techniques had a major impact on adhesionrelated complications. This meta-analysis provides little evidence that less invasive techniques, less foreign body material and less ischaemic injury reduce the extent and severity of adhesions in humans. The total prevention of adhesion formation is the only means to prevent an adhesion-related complication. It is not expected that optimal surgical technique alone will achieve this goal, based on the inevitable peritoneal injury inflicted by any type of surgery. As a consequence, there continues to be a need for anti-adhesion barriers and agents in open and laparoscopic surgery (32).

Implications for clinical practice and future research
Improved medical treatment for Crohns disease and ulcerative colitis has significantly reduced the number of surgeries and thereby the number of planned enterostomy take downs during which adhesions can be scored (33,34).

Cine-MRI especially holds promise identifying both adhesions to the abdominal wall and between abdominal viscera (35,36).

The total prevention of adhesion formation is the only means to prevent an adhesion-related complication. It is not expected that optimal surgical technique alone will achieve this goal, based on the inevitable peritoneal injury inflicted by any type of surgery. As a consequence, there continues to be a need for anti-adhesion barriers and agents in open and laparoscopic surgery (33,36).

CONCLUSION
intrapерitoneal adhesions remain a primary concern, not only as a risk factor for laparoscopy (especially abdominal entry) but also as a result of surgery. Many modalities are being studied to reduce this risk, however none can eliminate the risk of adhesion formation. Knowledge of the risk factors, good surgical technique to minimize tissue trauma and utilization of proper instruments and ancillary technology has shown to decrease complications and the severity of adhesion formation.

REFERENCES
Figure 1: Prisma chart illustrating the selection procedure of relevant articles. RCT, randomized clinical trial.
<table>
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<th>Study</th>
<th>Period</th>
<th>Patients</th>
<th>Interventions</th>
<th>Procedures</th>
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<th>Outcomes</th>
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A Systematic Review and Meta-Analysis…

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NR: not reported.

*Randomization unit is ovary.