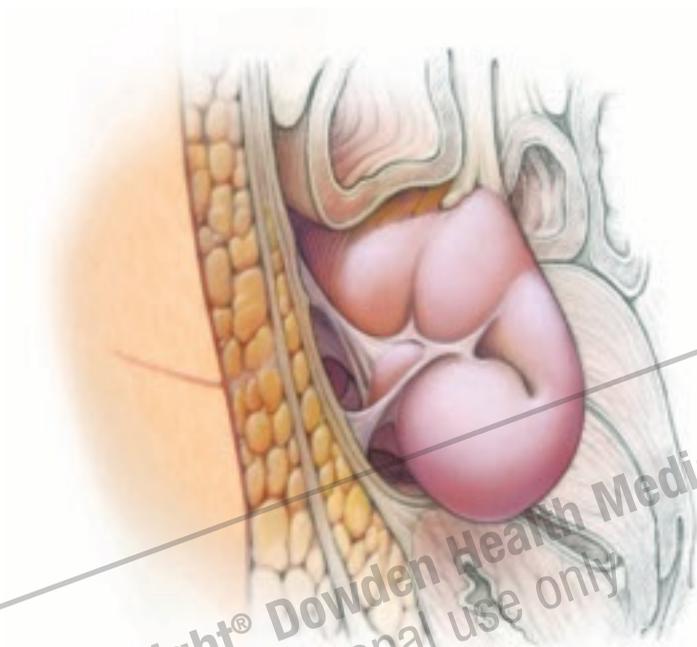


**Togas Tulandi, MD, MHCM**  
Professor of Obstetrics and  
Gynecology, Milton Leong Chair  
in Reproductive Medicine,  
McGill University, Montreal, Quebec

**Mohammed Al-Sunaidi, MD**  
Fellow in Reproductive  
Endocrinology and Infertility,  
McGill University, Montreal, Quebec

*The authors report no financial  
relationships relevant to this article.*



Adhesions that form between the small bowel and abdominal wall can cause severe constrictions that obstruct the bowel.

© Scott Bodell

## Averting adhesions: Surgical techniques and tools

### IN THIS ARTICLE

**I Adhesion barriers and instillates, and how they work**

Page 88

**I Adhesions through the laparoscope**

Page 91

**I Which operations are the biggest culprits?**

Page 92

A laparoscopic approach, microsurgical principles, and barriers or instillates can reduce adhesions

### **CASE** Could bowel obstruction have been prevented?

B.H., 34, undergoes laparotomy for removal of an 8-cm myoma and a left ovarian cyst, which is found to be an endometrioma. Now she has come to the emergency department complaining of abdominal distension, pain, vomiting, and an inability to defecate. Small-bowel obstruction is diagnosed. Another laparotomy reveals that the obstructed bowel is adhered to the prior surgical incision.

Could this scenario have been avoided?

Adhesions need no introduction. Every surgeon is familiar with them; they are so ubiquitous they sometimes seem to be

a given. Nevertheless, there are steps you can take to reduce the incidence of post-operative adhesions. In this article we describe surgical techniques, barriers, and peritoneal instillates that can help.

### **Why worry?**

Intra-abdominal adhesions can cause pain, infertility, and bowel obstruction, and complicate future surgeries.<sup>1-3</sup> Most studies suggest that more than 50% of women with adhesion-related small bowel obstruction have a history of gynecologic or obstetric operations. Within 1 year of laparotomy, adhesions cause intestinal obstruction in 1% of patients. After even a single previous abdominal operation, 93% of patients develop

adhesions, compared with only 10.4% of patients who have never undergone laparotomy (FIGURE 1, page 91).<sup>1-3</sup>

We recently found an incidence of adhesion-related intestinal obstruction after operation for a benign gynecologic indication of 8 cases per 1,000 operations.<sup>4</sup> Total abdominal hysterectomy (TAH) was the most common cause of small bowel obstruction (13.6 cases per 1,000 surgeries).

## Surgical technique

### Basic strategies

Tissue desiccation, necrosis, and the use of reactive suture material can predispose the patient to adhesion formation. Many studies in animal models have demonstrated an association between adhesions and these parameters. The following practices can help:

- Continuously irrigate the operative field during laparotomy
- Use nonreactive suture material such as polyglycolic acid (Dexon), polyglactin (Vicryl), or polydioxanone (PDS). Using reactive material, such as catgut, is discouraged
- Use powder-free gloves and prevent foreign-body infiltration (eg, powder, gauze, lint) of the wound.

No single parameter is as important as good surgical technique, attention to microsurgical principles, and precise hemostasis (TABLE 1).

### Peritoneal closure is unnecessary

Several randomized trials have demonstrated that closure of the parietal or visceral peritoneum is unnecessary. This practice is associated with slightly longer operating times and greater postoperative pain and may cause more adhesions.<sup>5</sup> In 1 study, the rate of adhesion formation after laparotomy with peritoneal closure was 22.2%, compared with 16% without closure.<sup>6</sup>

Ellis<sup>7</sup> noted an increasing number of medicolegal claims arising from adhesion-related complications, and recom-

**TABLE 1**

### Surgical principles to reduce adhesion formation

Take a laparoscopic approach when feasible
Minimize tissue necrosis
Provide meticulous hemostasis
Liberally irrigate the abdominal cavity
Use nonreactive suture materials
When performing laparotomy <ul style="list-style-type: none"> <li>• Avoid contamination with glove powder, lint, or other foreign bodies</li> <li>• Do not suture the peritoneum</li> </ul>

mended that “peritoneal defects and the pelvic floor should be left open, since they rapidly reperitonealized.”

### Laparoscopy is more protective than open surgery

Abdominal surgeries injure tissues more severely than laparoscopy, and are associated with a greater degree of adhesion formation in up to 94% of patients, although laparoscopy can also cause adhesions.<sup>2</sup> Laparoscopy is more protective because it involves minimal handling of tissue and little manipulation of the internal organs. Surgery is performed in a closed environment, tissue moisture is maintained, and contamination with glove powders or lint does not occur. In addition, the tamponade effect of carbon dioxide pneumoperitoneum facilitates hemostasis. Laparoscopy is also associated with a lower incidence of infection.

### Adhesion-reducing substances

Many adhesion-reducing products have been evaluated in human and animal models. A basic assumption behind these substances is that surgically injured tissues heal without forming adhesions if the traumatized surfaces in apposition are separated to allow each to heal independently.

CONTINUED

### FAST TRACK

**To reduce the likelihood of adhesions, do not suture the peritoneum after abdominal operations**

**TABLE 2**

**The array of selected adhesion barriers and peritoneal instillates, and how they work**

PRODUCT	SPECIAL FEATURES
<b>Barriers</b>	
Expanded polytetrafluoroethylene (Preclude [Gore-Tex surgical membrane])	<ul style="list-style-type: none"> <li>• Very effective</li> <li>• Nonreactive</li> <li>• Nondegradable</li> <li>• Requires fixation to the tissue</li> <li>• Difficult to apply by laparoscopy</li> <li>• Unpopular</li> </ul>
Hyaluronic acid and carboxymethylcellulose (Septrafilm)	<ul style="list-style-type: none"> <li>• Blood-insensitive</li> <li>• Brittle and sticky</li> <li>• Difficult to use by laparoscopy</li> </ul>
Oxidized regenerated cellulose (Interceed [TC7])	<ul style="list-style-type: none"> <li>• The most widely studied material</li> <li>• Easy to handle</li> <li>• Blood-sensitive</li> </ul>
<b>Instillates</b>	
4% icodextrin (Adept)	<ul style="list-style-type: none"> <li>• Requires high volume (1 L)</li> <li>• Decreases adhesion formation and reformation after laparoscopic gynecologic surgery</li> </ul>
Hyaluronic acid and ferric ion (InterGel)	<ul style="list-style-type: none"> <li>• Effective</li> <li>• Withdrawn from market</li> </ul>
HAL-C bioresorbable membrane (Septracoat)	<ul style="list-style-type: none"> <li>• Absorbed within 7 days</li> <li>• Reduces tissue desiccation</li> </ul>
Hydrogel (SprayGel) to form membrane	<ul style="list-style-type: none"> <li>• Two polymers must be combined</li> <li>• Sprayable</li> <li>• Easy to use at laparoscopy</li> <li>• Pivotal study stopped prior to completion</li> </ul>
Hydrogel (Adhibit)	<ul style="list-style-type: none"> <li>• Not available in the US</li> </ul>
Fibrin sealant (Tissucol)	<ul style="list-style-type: none"> <li>• Scarce data</li> </ul>

The ideal substance is resorbable, adherent to the traumatized surface, applicable through the laparoscope, and inexpensive, with high biocompatibility. So far, no substance or material has proved to be unequivocally effective.

**Adhesion barriers are widely studied**

The following products are among the most widely investigated substances (TABLE 2).

**Expanded polytetrafluoroethylene, or**

**ePTFE.** Gore-Tex surgical membrane, constructed of ePTFE (Preclude, WL Gore), is nonabsorbable and produced in thin sheets (0.1 mm), with an average pore size of less than 1 μm. It is sutured to the tissue so that it overlaps the incision by at least 1 cm. It prevents adhesion formation—and reformation—independent of the type of injury. It is also effective in the presence of blood.

In a randomized trial, ePTFE decreased postmyomectomy and pelvic sidewall adhesions.<sup>8,9</sup> In our experience, this is the most effective adhesion-reducing substance available. It is not widely used, however, because it is nonabsorbable and has to be fixed to the tissue.

**Combined hyaluronic acid (HA) and carboxymethylcellulose (CMC).** Known most widely by its trade name, Septrafilm (Genzyme Corp), this bioresorbable product is composed of sodium HA and CMC, a combination that produces a transparent and absorbable membrane that lasts for 7 days after application.<sup>10,11</sup>

In a study of 259 patients undergoing laparotomy for bowel resection or enterolysis, the incidence of repeat bowel obstruction was similar in the group treated with Septrafilm and the historical control group.<sup>11</sup> However, 9 of 12 bowel obstructions in the treated group resolved without surgery, compared with 5 of 12 in the control group. The enterolysis rate in the treated group was 1.5%, compared with 3.9% in the control group.

Because of its stickiness, Septrafilm is not ideal for laparoscopy. However, it can be rolled and passed through the trocar, with the film separated from its paper backing inside the abdominal cavity.

**Oxidized regenerated cellulose.** Known under the brand name Interceed (TC7), this absorbable adhesion barrier (Johnson & Johnson) is the most widely studied product available today. Several randomized trials have shown that it reduces postoperative formation of adhesions on the pelvic sidewalls and near the adnexa.<sup>12-14</sup>

CONTINUED

The efficacy of Interceed is reduced in the presence of blood. It is the easiest adhesion barrier to use at laparoscopy.

Newer agents in development include CMC and polyethylene oxide (PEO) composite gel (Oxiplex/AP, FrizoMed) and polylactide (PLA): copolymer of 70:30 Poly (L-lactide-co-D,L-lactide) film (SurgiWrap, Mast Biosurgery).

### Peritoneal instillates

The newest peritoneal instillate is 4% icodextrin solution (Adept, Baxter BioSurgery). It is FDA-approved for the reduction of adhesion reformation after laparoscopic adhesiolysis. In a randomized study, the authors found that instillation of 4% icodextrin solution decreased adhesion formation and reformation after laparoscopic gynecologic surgery.<sup>15</sup>

**Hyaluronic acid.** Intergel (Lifecore, Johnson & Johnson Gynecare) is a cross-linked HA with ferric ion. It effectively reduces the number, severity, and extent of adhesions after abdominal operation.<sup>16</sup> However, the product was withdrawn from the market after several reports of late-onset postoperative pain requiring surgery.

**Sepracoat.** This product (HAL-C Bioresorbable Membrane, Genzyme Corp) is a modification of Sefrafilm. It coats serosal surfaces and is absorbed from the peritoneal cavity within 7 days. Its mechanism of action includes the reduction of tissue desiccation. Preliminary data show it to be effective in reducing postoperative adhesions.<sup>17</sup> However, it did not receive FDA approval for clinical use, and was withdrawn from the market in 1997.

**Hydrogel.** A novel technique of substance delivery into the abdominal cavity is by combining 2 streams of liquid polymers, delivered via catheter to target tissue. When combined, the 2 streams produce a solid polymer within minutes. Sprayable hydrogel (SprayGel, Confluent Surgical) can be easily applied at laparoscopy. The solid polymer acts as an adhesion barrier

**FIGURE 1**

### Adhesions through the laparoscope



Severe adhesions between the intestines and omentum to the uterus.



Omental adhesions to the anterior abdominal wall.



Adhesion between the intestine (lower left hand corner) and the anterior abdominal wall.

and can potentially serve as a vehicle for localized delivery of drugs.

In a randomized study, Mettler et al<sup>18</sup> evaluated 66 women who underwent myomectomy with or without SprayGel application. Second-look laparoscopy was performed in 40 women. Seven of 22 patients (31.8%) in the SprayGel

### FAST TRACK

**A novel technique is to combine 2 streams of liquid polymer via catheter to produce a solid polymer over the target tissue**

group and 2 of 18 patients (11.1%) in the control group remained free of adhesions. However, the power of this study is small, and the authors did not break the women into subgroups based on whether they underwent surgery via laparoscopy or laparotomy. In the United States, the pivotal study of SprayGel was stopped prior to completion.

A similar product is a sprayable self-polymerizing gel called Adhibit (Angiotech). An unpublished study from Europe showed it to be promising.

**Fibrin sealant.** Fibrin glue (Tissucol, Baxter) has been used as an adhesion-reducing substance, although clinical data on this application are scarce. This product is not approved by the FDA.

### Which operations are the biggest culprits?

#### Myomectomy

Myomectomy performed through a laparotomy incision usually causes adhesions, so women who undergo this operation are good candidates for adhesion-reducing substances. The rate of adhesion formation after abdominal myomectomy is more than 90%—and it is 70% by laparoscopy.

Two helpful preventive strategies:

- Use a laparoscopic approach when feasible, and
- apply a barrier, such as the Gore-Tex ePTFE membrane, Seprafilm, or, if the myomectomy incision is not oozing, Interceed. Instillation of 1 L of 4% icodextrin may also be useful.

#### Hysterectomy

Most small-bowel obstruction follows abdominal hysterectomy, although a considerable period of time may pass before the problem occurs. When it does, a general surgeon usually manages the patient, and the treating gynecologist is unaware of this serious complication.

We recently found an incidence of adhesion-related small-bowel obstruction of 14 cases per 1,000 total abdomi-

nal hysterectomies and 1 case per 1,000 vaginal hysterectomies ( $P < .001$ ).<sup>4</sup> We did not encounter any small-bowel obstruction among 303 cases of laparoscopic supracervical hysterectomy.

Application of an adhesion-reducing substance to the vaginal vault or cervical stump may prevent small-bowel obstruction. Most adhesions implicated in small-bowel obstruction involve the vaginal vault. Appropriate products include Interceed, Preclude, Seprafilm, or perhaps Adept.

#### Fertility-promoting surgery

No adhesion-reducing substance has proved to be effective in increasing the pregnancy rate after a fertility-promoting procedure such as reconstructive tubal surgery or surgery for endometriosis.

### CASE Recommendations

**B.H.**, the patient described at the beginning of this article, should have had her initial surgery performed by an experienced laparoscopist, with minimal coagulation, meticulous hemostasis, “layered” repair of the myomectomy incision using nonreactive sutures, and liberal irrigation of the abdominal cavity. At the conclusion of the operation, the incision could have been covered with Gore-Tex surgical membrane or Seprafilm (or Interceed if there was no oozing) at least 1 cm beyond the incision. Instillation of Adept might have been useful as well.

The second operation also should have involved a laparoscopic route, which is associated with a lower rate of adhesions and could have reduced her risk of further bowel obstruction. ■

#### References

1. Diamond MP. Incidence of postsurgical adhesions. In: diZerega G, ed. *Peritoneal Surgery*. New York: Springer-Verlag; 2000:217–223.
2. Tulandi T, Al-Shahrani A. Adhesion prevention in gynecologic surgery. *Curr Opin Obstet Gynecol*. 2005;17:395–398.
3. Al-Took S, Platt R, Tulandi T. Adhesion-related small bowel obstruction after gynecologic operations. *Am J Obstet Gynecol*. 1999;180:313–315.

CONTINUED

### FAST TRACK

**No adhesion-reducing substance can improve the pregnancy rate after fertility-promoting surgery**

4. Al-Sunaidi M, Tulandi T. Adhesion-related bowel obstruction after hysterectomy for benign conditions. *Obstet Gynecol.* 2006;108:1162-1166.
5. Tulandi T, Al-Jaroudi D. Non-closure of peritoneum: a reappraisal. *Am J Obstet Gynecol.* 2003;189:609-612.
6. Tulandi T, Hum HS, Gelfand MM. Closure of laparotomy incisions with or without peritoneal suturing and second-look laparoscopy. *Am J Obstet Gynecol.* 1988;158:536-537.
7. Ellis H. Medicolegal consequences of postoperative intra-abdominal adhesions. *J R Soc Med.* 2001;94:331-332.
8. Franklin R, Haney A, Kettel L, et al. An expanded polytetrafluoroethylene barrier (Gore-Tex surgical membrane) reduces post-myomectomy adhesion formation. Myomectomy Adhesion Multicenter Study Group. *Fertil Steril.* 1995;63:491-493.
9. Haney A, Hesla J, Hurst B, et al. Expanded polytetrafluoroethylene (Gore-Tex surgical membrane) is superior to oxidized regenerated cellulose (Interceed TC7) in preventing adhesions. *Fertil Steril.* 1995;63:1021-1026.
10. Diamond MP, and the Seprafilm Adhesion Study Group. Reduction of adhesions after uterine myomectomy by Seprafilm membrane (HAL-F): a blinded, prospective, randomized, multicenter clinical study. *Fertil Steril.* 1996;66:904-910.
11. Vrijland WW, Tseng LN, Eijkman HJ, et al. Fewer intraperitoneal adhesions with use of hyaluronic acid-carboxymethylcellulose membrane: a randomized clinical trial. *Ann Surg.* 2002;235:193-199.
12. Sekiba K. The use of Interceed (TC7) absorbable adhesion barrier to reduce postoperative adhesion reformation in infertility and endometriosis surgery. Obstetrics and Gynecology Adhesion Prevention Committee. *Obstet Gynecol.* 1992;79:518-522.
13. Azziz R, and the Interceed (TC7) Adhesion Barrier Study Group II. Microsurgery alone or with Interceed absorbable adhesion barrier for pelvic side wall adhesion reformation. *Surg Gynecol Obstet.* 1993;77:135-139.
14. Nordic Adhesion Prevention Study Group. The efficacy of Interceed (TC7) for prevention of reformation of postoperative adhesions on ovaries, fallopian tubes, and fimbriae in microsurgical operations for fertility: a multicenter study. *Fertil Steril.* 1995;63:709-714.
15. DiZerega GS, Verco SJ, Young P, et al. A randomized, controlled pilot study of the safety and efficacy of 4% icodextrin solution in the reduction of adhesions following laparoscopic gynaecological surgery. *Human Reprod.* 2002;17:1031-1038.
16. Hill-West JL, Dunn RC, Hubbell JA. Local release of fibrinolytic agents for adhesion prevention. *J Surg Res.* 1995;59:759-763.
17. Diamond MP. Reduction of de novo postsurgical adhesions by intraoperative precoating with Sepracoat (HAL-C) solution: a prospective, randomized, blinded, placebo-controlled multicenter study. The Sepracoat Adhesion Study Group. *Fertil Steril.* 1998;69:1067-1074.
18. Mettler L, Audebert A, Lehmann-Willenbrock E, Schive-Peterhansl K, Jacobs VR. A randomized, prospective, controlled, multicenter clinical trial of a sprayable, site-specific adhesion barrier system in patients undergoing myomectomy. *Fertil Steril.* 2004;82:398-404.

rely solely on this mobility to determine whether or not a trial of forceps or vacuum is indicated. Because the basovertical diameter of the fetal head can be elongated, it is possible to palpate the leading edge of the skull below the ischial spines and still have an unengaged fetal head. This is exactly the circumstance in which a vaginal examination will give false reassurance of the chance of success. In this circumstance, although part of the skull is below the plane of the ischial spines, the widest diameter of the fetal head (usually the biparietal diameter) is still above the plane of the maternal pelvic brim, and the fetal head is unengaged.

I would argue against moving ahead with a "trial of forceps in the OR" in cases with a "tight fit." As discussed in the article, significant molding implies stretching of the underlying soft tissue. In my opinion, proceeding with an operative vaginal delivery in the case of a fetus with 3+ molding would be riskier than is justified. Operative vaginal delivery should be offered only when it is almost certain to succeed. For that reason, I would also caution against using a trial of forceps in cases where the outcome is uncertain. Cesarean section may be the safest option in such cases.

I agree completely that liberal use of ultrasound to determine head position and station (if possible) should be encouraged.

I recommend that any forceps delivery that is anything other than an outlet delivery take place in the operating room. In addition, I recommend always having neonatal and anesthesia backup readily available with any operative vaginal delivery attempt unless it is an emergency.

Finally, I agree that the correct application of the forceps is essential. In fact, the most important part of the forceps procedure is what happens before the actual application of traction! If the correct indications have been followed, the patient has been properly assessed and prepared for the procedure, and if all ancillary services are available, the traction effort is usually the least stressful part of the delivery, since it is bound to succeed. ■