ABSTRACT

Background: Adhesions commonly result from abdominal and pelvic surgical procedures and may result in intestinal obstruction, infertility, chronic pain, or complicate subsequent operations. Laparoscopy produces less peritoneal trauma than does conventional laparotomy and may result in decreased adhesion formation. We present a review of the available data on laparoscopy and adhesion formation, as well as laparoscopic adhesiolysis. We also review current adjuvant techniques that may be used by practicing laparoscopists to prevent adhesion formation.

Database: A Medline search using “adhesions,” “adhesiolysis,” and “laparoscopy” as key words was performed for English-language articles. Further references were obtained through cross-referencing the bibliography cited in each work.

Discussion: The majority of studies indicate that laparoscopy may reduce postoperative adhesion formation relative to laparotomy. However, laparoscopy by itself does not appear to eliminate adhesions completely. A variety of adjuvant materials are available to surgeons, and the most recent investigation has demonstrated significant potential for intraperitoneal barriers. Newer technologies continue to evolve and should result in clinically relevant reductions in adhesion formation.

Key Words: Adhesions, Adhesiolysis, Laparoscopy.

INTRODUCTION

One seemingly unalterable fact of abdominal and pelvic surgery is that adhesions develop after surgical procedures. Adhesions may develop between solid organs, the intestines, fallopian tubes, omentum, or the abdominal wall. In fact, adhesions can develop between any 2 abdominal surfaces during the healing process.

Previous reports described a high rate of adhesion formation. In the largest autopsy series of abdominal adhesions, 752 subjects, 44.5% had adhesions (67% in patients with prior surgery and 28% in patients without surgery). After multiple laparotomies, the incidence of adhesions may be as high as 93%.

The consequences and complications of adhesions are substantial. Ray’s 1994 landmark review found that adhesiolysis was responsible for over 300,000 hospital admissions in the United States and a staggering $1.3 billion in direct hospital and surgical expenses. Similarly, Ellis found that over 10 years after initial surgery, 5.7% of hospital readmissions in Scotland were directly attributable to adhesions.

Adhesions impact all surgeons who perform abdominal or pelvic surgery, including gynecologists, urologists, and general surgeons. The aim of this paper is to provide a multispecialty review of the current literature on the impact of laparoscopy on adhesion formation and treatment. Newer adjuvant treatments that may be used in conjunction with laparoscopic surgery are also reviewed.

METHODS OF REVIEW

A Medline search was conducted of the English-language literature from 1966 to the present, using the key words “adhesions,” “adhesiolysis,” and “laparoscopy.” Results from each search were combined to maximize the number of articles included. Further references were obtained through a review of the bibliography of each article.

ETIOLOGY

Adhesions may be congenital in origin or develop secondary to intraabdominal inflammation. Some adhesions may develop as a consequence of endometrio-
sis, ischemia, or infection. In the United States, it is generally accepted that the most common cause is secondary to prior operative intervention.

The pathophysiology of adhesion formation has recently been reviewed elsewhere. Briefly, disruption of the mesothelial surface of the peritoneum is followed by fibrin deposition and bleeding. A fibrinous matrix develops, and a gelatinous connection is made to adjacent structures, followed by ingrowth of fibroblasts to form a permanent adhesion. In the absence of adhesion formation, the mesothelial surface repairs itself in about 5 to 7 days.

The study of adhesions has been hampered by the lack of a uniform animal model. Both the species involved and the type of experimental injury created has varied considerably, prompting 1 group to dub the literature “a veritable barnyard.” Most animal studies have been performed in the rat or rabbit model. These species, however, have proportionately less omentum than humans do, which may be a significant limitation.

COMPLICATIONS OF ADHESIONS

The mere presence of adhesions does not condemn the patient to clinically important complications. In certain cases of abscess or leakage from suture lines, adhesions may contain or limit the pathology and consequently be protective. However, adhesions are directly implicated in several common complications observed in abdominal and pelvic surgery: intestinal obstruction, infertility, and abdominal pain.

Intestinal Obstruction

Upwards of one third of all cases of intestinal obstruction are secondary to adhesions. One survey estimated 4% of laparotomies in Sweden were performed for adhesive bowel obstructions. Further, adhesions occur rapidly after surgical procedures. A review of 18,912 patients with open abdominal surgery found 14.3% had obstruction within 2 years, with 2.6% requiring adhesiolysis. Other studies demonstrated that over one third of patients with obstruction presented within 1 year of surgery. Importantly, over 10% developed recurrent obstruction, illustrating our incomplete understanding of adhesion prevention.

Infertility

The effect of minimal adhesions on fertility is unknown. However, if the ovary, fallopian tube, or uterus is confined to a fixed position where normal function is impeded or impossible, impaired fertility may result. In this manner, moderate to severe pelvic adhesions may be responsible for 40% of infertility. Patients with a history of ovarian manipulation or surgery are particularly subject to adhesion formation.

Successful pregnancy outcome after adhesiolysis has been a controversial topic. Lysis of mild, filmy adhesions may not improve subsequent fertility rates. Other authors report pregnancy success rates approaching 50% in patients with more advanced adhesive disease. However, in vitro fertilization technology may produce similar pregnancy rates without the associated risks of surgical intervention.

Chronic Pain

Adhesiolysis has a role in the treatment of chronic abdominal and pelvic pain; however, the resolution of pain does not always correlate with lysis of adhesions. Recent studies have demonstrated that laparoscopic adhesiolysis effectively reduces the subjective assessment of pain in some patients, although this effect may be transient and pain may recur after several months. Unfortunately, no large prospective trials have studied the incidence of reformation of adhesion after laparoscopic lysis, and some authors have suggested that pain relief after laparoscopic adhesiolysis only represents a placebo effect.

Other Complications

Voiding dysfunctions like urinary frequency and ureteral obstruction have been described. Less commonly, adhesions may interfere with intraperitoneal therapy, such as dialysis catheters or chemotherapy. Lastly, adhesions increase the technical difficulty of subsequent intraabdominal procedures. One study noted 6% of laparotomies were directly complicated by adhesions from previous operations.
LAPAROSCOPY AND ADHESION FORMATION

Proponents of laparoscopic surgery cite many potential benefits of laparoscopy that may minimize adhesion formation after abdominal and pelvic procedures. First, trauma to the peritoneum is minimized relative to open surgery. In 1 review, 71% of adhesions involved the laparotomy scar. Procedures that decrease the size of the surgical wound, such as laparoscopy, may then result in decreased adhesion formation. Second, the potential exists for reduced intraabdominal contact with foreign bodies, such as gauze sponges, that lead to development of adhesions. Further, laparoscopic surgery may maintain native tissues in a humid environment, which may protect the bowel against serosal abrasions. Laparoscopy also offers the promise of less tissue trauma, less hemorrhage, or less of both of these at the operative site. The fact that pneumoperitoneum is established may separate healing surfaces and decrease the tendency for adhesion formation. In addition, the potential to view the entire abdominal cavity allows visualization of inflammatory pathology distant to the operative site that may contribute to adhesion formation.

Critics, however, contend that visceral injury might be more pronounced in the unfamiliar laparoscopic arena. Additionally, the pneumoperitoneum used in laparoscopic surgery may have its own deleterious effects. One study found adhesion formation in rabbits increased with intraabdominal pressure. Some component was probably due to the high CO₂ content, while desiccation due to the high flow rate of insufflating gas played a separate role. Elevated intraabdominal pressure may also result in local hypoxia that itself may potentiate adhesion formation.

Several direct comparisons of the impact of laparoscopy and laparotomy on adhesions have been performed and are summarized in Table 1. Differing study designs, animal models, and end points of evaluation preclude meta-analysis, but a preponderance of evidence (7 of 12 studies) found laparoscopy to be beneficial in reducing adhesions, including all 3 human trials. However, 4 studies found no difference between laparoscopy and laparotomy, and 1 demonstrated fewer adhesions after laparotomy.

The most cited study in which laparoscopy was found to reduce adhesions was a randomized trial comparing laparoscopy and laparotomy for the development of abdominal adhesions after tubal pregnancy and was conducted by Lundorff et al. Seventy-three patients were diagnosed with ectopic pregnancy, treated with laparoscopy or laparotomy, and had a second-look procedure 12 weeks later. Those patients treated by laparoscopic means developed significantly fewer adhesions than the patients treated by laparotomy. Additionally, the adhesions that did develop in the laparoscopy group were noted to be less severe than before lysis.

In contrast, the Operative Laparoscopy Study Group published its findings of second-look laparoscopy evaluation of laparoscopic adhesiolysis in 1991. After laparoscopic adhesiolysis, 97% of patients developed postoperative adhesions within 3 months at the same sites for which they underwent the initial procedure. Importantly, de novo adhesion formation was reported in only 12% of patients. This rate of de novo formation compares favorably with previously reported laparotomy experiences, but the overall reformation rate suggests laparoscopy is not effective in eliminating all adhesions.

Numerous studies have been conducted in the porcine model. Garrard et al studied mesh placement by laparotomy, laparoscopy, and laparoscopy combined with a midline skin incision. No adhesions occurred in the laparoscopic group at 3-week follow-up. Interestingly, adhesions were increased when a midline skin incision that did not penetrate the fascial plane was added to the laparoscopy. This intriguing finding again reinforces the fact that our knowledge of adhesion formation remains incomplete.

In another study, laparoscopy produced adhesions in 25% of lymph-adenectomies, whereas laparotomy produced adhesions in 100% of pigs. To counter these findings, a separate study of 62 herniorrhaphies in pigs showed that 48% of the animals with laparoscopic surgery developed adhesions as determined by second-look laparoscopy 4 to 6 weeks later. None of the pigs that underwent open herniorrhaphy developed adhesions.

Additional trials studying laparoscopy alone, mostly in human clinical trials, are listed in Table 2. Most studies indicated that laparoscopy was beneficial. However, these trials did identify adhesion reformation after laparoscopic adhesiolysis in 20% to 97% of patients. Clearly, at present, the definitive answer has not yet been determined. The benefits of laparoscopic surgery, such as reduced postoperative pain, reduced morbidity, and
### Table 1.
Comparisons of adhesion formation in laparoscopy and laparotomy.

| Author (year)     | Animal (#) | Model                                      | Assessment          | Results                                                                 |
|------------------|------------|--------------------------------------------|---------------------|--------------------------------------------------------------------------|
| Audebert (2000)²⁶| Human (345) | Umbilical adhesions after prior laparotomy or laparoscopy | Laparoscopy         | Adhesions: 1.6% after laparoscopy, 34% laparotomy                       |
| Chen (1998)²⁷    | Pig (90)    | Pelvic/Para-aortic lymphadenectomy          | Laparotomy (5 weeks) | No difference                                                            |
| Eller (1997)²⁸   | Pig (62)    | Herniorrhaphy                              | Laparoscopy (4-6 weeks) | Laparotomy-0, laparoscopy-48% adhesions                                 |
| Filmar (1987)²⁹  | Rat (61)    | Uterine horn injury                        | Laparotomy (2 weeks) | No difference                                                            |
| Garrard (1999)³⁰ | Pig (21)    | Mesh placement                             | Laparotomy (3 weeks) | Area/extent of adhesions increased with laparotomy or midline incision   |
| Jorgensen (1995)³¹| Rabbit (20) | Cecal/parietal serosal injury               | Laparotomy (1 week)  | No difference                                                            |
| Krähenbühl (1998)³²| Rat (52)    | Fundoplication                             | Laparotomy (3 weeks) | Laparoscopy produced less dense and fewer adhesions                      |
| Luciano (1989)³³ | Rabbit (20) | Uterine horn and peritoneal injury         | Laparotomy/Laparoscopy (6 weeks) | Laparoscopy reduced adhesion formation                                  |
| Lundorff (1991)³⁴| Human (73)  | Tubal pregnancy                            | Laparoscopy (12 weeks) | Laparoscopy significantly fewer adhesions                               |
| Marana (1994)³⁵  | Rabbit (28) | Ovarian injury                             | Laparoscopy (6 weeks) | No difference                                                            |
| Milingos (2000)³⁶| Human (21)  | Perineal adhesions causing infertility      | Laparoscopy (3-6 months) | Slight reduction in adhesions in laparoscopic arm                       |
| Schippers (1998)³⁷| Dog (14)    | Cecal resection                            | Laparotomy (8 days)  | Laparoscopy significantly fewer and smaller adhesions                   |

decreased length of stay, have solidified the role of laparoscopy in clinical surgery. However, due to the conflicting results of these published studies, the topic of adhesion formation in laparoscopy remains controversial.

In some instances, laparoscopic surgery may be performed extraperitoneally, as in cases of nephrectomy or preperitoneal hernia repair. Despite the fact that the peritoneum is not violated, the procedure may still predispose to the formation of adhesions. One study of rats (N = 50) demonstrated a reduction in the rate of adhesion formation of greater than 50% when an extraperitoneal approach was used. However, adhesions still developed in half of the animals. These results have also been confirmed in the murine model, where 1 group demonstrated adhesions in 23% of animals in which the peritoneum was dissected from the abdominal wall versus 7% in the nondissected group. Although human data are lacking, the animal experience suggests that the total-
ly extraperitoneal laparoscopic procedure may still result in intraabdominal adhesions.

Thus, it seems that laparoscopy is not a panacea for the prevention or treatment of adhesions. Like traditional open surgery, minimally invasive surgery necessarily involves peritoneal and tissue trauma. It seems likely that laparoscopy may provide a reduced but nonzero incidence of adhesion formation.49

### GRADING SYSTEMS

To date, no universal grading system exists to score adhesions. One study that assessed interobserver variability concluded that the American Fertility Society classification was not an appropriate basis for comparison between centers and did not accurately gauge prognosis.50 In fact, no system has been validated at present.

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**Table 2.**

| Author (year) | Animal (§) | Model | Assessment | Results |
|---------------|-------------|-------|------------|---------|
| Chen (1997)20 | Human (10)  | Adhesiolysis | Symptomatic relief of pain or frequency | 78% improved after lysis |
| El Dahha (1999)39 | Human (14) | Adhesiolysis | Immediate relief of intestinal obstruction | 14% conversion, 7.1% morbidity, LOS 3.7 days |
| Gomel (1983)40 | Human (92) | Salpingo-ovariolysis | Pregnancy | 62% pregnant |
| Gürgan (1992)13 | Human (19) | Ovarian photo-coagulation | Laparoscopy (3-4 weeks) | 13 pts had minimal adhesions, lysis did not improve fertility |
| Malik (2000)17 | Human (101) | Adhesiolysis | Pain relief | Partial or complete Relief in most patients |
| Mecke (1989)11 | Human (33) | Ectopic treatment | Laparoscopy (4 mo-2 yrs) | 52% re-formed adhesions |
| Naether (1993)12 | Human (62) | Ovarian electro-coagulation | Laparoscopy (2-943 days) | 19.3% formed adhesions |
| Nezhat (2000)18 | Human (48) | Adhesiolysis for chronic pain | Survey (2 mo, 1 yr, 2-5 yrs) | 72% significant initial relief, 67% long-term relief |
| Operative Laparoscopy Study Group (1991)38 | Human (68) | Adhesiolysis | Laparoscopy (< 3 months) | 97% re-formed, 12% de novo adhesions |
| Perez (1991)33 | Human (38) | Adhesiolysis 1 week after laparotomy | Laparoscopy (6-18 months) | 47% adhesion-free after lysis by laparoscopy |
| Siegert (2000)44 | Human (19) | Adhesiolysis | Clinical relief obstruction or pain (11 mos) | 84% symptom-free, 10.5% converted to open procedure |
| Vader (1997)45 | Pig (108) | Herniorrhaphy | Laparotomy (3 days, 3 wks, 3 mos) | Peritoneum protects against adhesions |
ADHESIOLYSIS

Indications for lysis of adhesions must be individualized to the patient. Certainly, in cases of acute abdomen secondary to intestinal obstruction or perforation, immediate operation and resection are indicated. However, surgery is by no means an absolute. In 1 prospective report, only 46% of patients presenting with radiographic and clinical evidence of bowel obstruction secondary to adhesions required operative intervention. In cases of chronic pain or even infertility, lysis of adhesions may be considered an elective procedure.

Recognition of the problems that adhesions may cause led to the development of “second-look” procedures to assess adhesiolysis after gynecologic surgery. However, second-look procedures may have adverse effects. In 1 animal trial, lysis of adhesions within 1 week was ineffective, detrimental at 21 days after the injury, but beneficial at 14 days after injury. Because of the complex nature of such experimental evidence, clinicians face the challenge of extrapolating the data themselves to determine the optimal means of preventing and treating adhesions.

Methods

The actual modality of dividing adhesions has not been found to be a critical variable. The use of lasers in treatment of adhesions attracted some early attention, because lasers had the theoretical advantages of increased dissecting precision and minimal lateral tissue damage. However, later investigation found no distinguishable difference between electrocautery and the use of lasers. Well-developed adhesions may be highly vascularized, and care must be taken to ensure adequate hemostasis, whether it is by electrocautery, ligation, or harmonic scalpel.

COMPLICATIONS

Most commonly, adhesiolysis is complicated by injury to underlying structures like the intestines, uterus, ureters, or vascular structures. In particular, this injury may occur at the time of initial entry into the abdomen and is not obviated by use of the Hasson technique of “open” trocar placement.

Additionally, it has been suggested that a single adhesive band is more likely to cause clinical obstruction than a series of adhesive connections. If this is the case, then, unless all adhesions are removed, the incidence of obstruction may actually be increased by procedures that only decrease the number of adhesions. This theory will remain speculative, however, until it can be rigorously tested in an animal model.

PREVENTION OF ADHESIONS

The search for an adjuvant means to prevent adhesion formation traces its origins to the beginnings of the modern surgical era, such as Pope’s experiments with citrate solutions in 1914. Efficacious substances reported recently are listed in Table 3. The variety of agents underscores the lack of a single effective agent.

Most authors concede that the most important determinant of postoperative adhesion formation is surgical technique. One study found that operative experience was inversely correlated with adhesion formation. The principles of “microsurgery” or of minimizing surgical trauma to both the peritoneum and the viscera must be strictly followed. For example, mesh placed for hernia repair must be recognized as a potential focus for adhesions, and even peritonealization of the mesh may result in adhesion formation.

Table 3. Substances reported to diminish postoperative adhesion formation since 1985.

| Substance                        |
|---------------------------------|
| Aspirin                         |
| NSAIDs                          |
| Calcium channel blockers        |
| Octreotide                      |
| Carboxymethylcellulose          |
| Pentoxifylline                  |
| Chondroitin sulfate             |
| Peritoneal transplant           |
| Corticosteroids                 |
| Photopolymerized hydrogel       |
| Dextran                         |
| Polyethylene glycol             |
| Dialysis solution               |
| Polyoxymer 4074                 |
| Fibrin glue                     |
| Ringers lactate                 |
| Heparin                         |
| Saline                          |
| Hyaluronic acid                 |
| Surfactant                      |
| L-Arginine                      |
| Tissue plasminogen activator    |
| Mifepristone                    |
Systemic

At present, no systemic agent has proven clinically successful in preventing adhesions. Systemic agents do not seem to have the selectivity to alter peritoneal healing without undesired side effects. Corticosteroids may reduce adhesions but at the expense of disturbing the normal healing response. Calcium channel blockade was demonstrated to reduce adhesion formation in rabbits, but this has not yet been replicated in humans.

Gels and Solutions

Crystalloid solutions like high volumes of Ringer’s lactate were used as an early means of both physically separating healing surfaces and diluting exudate. However, they were resorbed by the peritoneum too quickly to prove beneficial. Analysis of studies from the early 1980s demonstrates an 80% rate of adhesion formation among crystalloid trials in pelvic surgery. An extensive review was performed in 1998, which noted that laparoscopy led to more adhesions than laparotomy in those studies using crystalloids, although the overall numbers were insufficient to draw definitive conclusions. Hyperosmolar solutions, such as peritoneal dialysis solution, may be reabsorbed more slowly and have been shown to be effective in rats. Hyaluronic acid (HA) may inhibit adhesion formation. One study in rat uterine horns demonstrated a significantly lower adhesion score when HA was injected intraperitoneally prior to injury. Also, this study found that addition of low-molecular-weight heparin or unfractionated heparin provided no significant benefit. A pilot study of an HA-based gel with 64 rats found that application of the gel produced no adhesions in 35% of rats and in only 5% of controls. However, the high viscosity of the gel made application difficult.

Carboxymethylcellulose (CMC) is a polysaccharide sometimes used as a food thickener. One study in the rat model found decreased adhesion formation after intraperitoneal instillation, but extrapolation to humans would require the use of 3 liters of CMC. Further, 1 additional study in rats demonstrated an adverse effect on the healing and bursting pressure of intestinal anastomoses when exposed to CMC.

A multitude of other substances has been utilized in the attempt to reduce adhesion formation. Dextran 70 met with initial clinical success, but later studies were unable to confirm its efficacy. Polyethylene glycol was found to be effective in the rat. Povidone significantly reduced postoperative adhesions to the small bowel but only in a canine model. Methylene blue was recently found by 1 group to decrease adhesion formation from 100% to 5% in rats. The specific mechanism of action has not been determined precisely but may involve the inhibition of oxygen radical formation. Thus, the quest for a single, non-toxic, easily applied, effective solution continues.

Intraperitoneal Barriers

Barrier methods have attracted the most recent attention for adhesion prevention. A series of recent elegant experiments with electron microscopy has demonstrated that adhesion formation does not progress after a mesothelial cell layer covers a foreign mesh at approximately 1 week. Hence, a barrier placed between healing surfaces for the first week after surgery may inhibit adhesion formation. Currently, 4 barriers are commercially available: hyaluronic acid (HA), carboxymethylcellulose (CMC), oxidized regenerated cellulose (ORC), and expanded polytetrafluoroethylene (ePTFE).

One clinical trial of 183 patients with ulcerative colitis or familial adenomatous polyposis studied the HA membrane in those undergoing colectomy and ileal pouch-anal anastomosis. Patients were evaluated 2 to 3 months later by laparoscopy during the second-stage ileostomy closure. Six percent of control patients were adhesion-free, whereas 51% with the HA membrane had no adhesions. Dense adhesions were noted in 58% of the control group but in only 15% of the group with the barrier. However, this trial found a significantly higher rate of intraperitoneal abscesses in treated patients. To dampen enthusiasm further, a separate group recently reported a case of severe inflammation after insertion of the HA membrane, resulting in repeat laparotomy for peritonitis.

HA-CMC (Seprafilm, Genzyme, Cambridge, MA) was found in 1 rat study to decrease the total number of adhesions formed without impairing wound healing. A more recent trial in the rat model not only found a significant reduction in adhesions but also found that adhesion formation did not progress after 7 days following the initial procedure. Large-scale human trials have not yet been conducted.
The newest of the barrier products adds polyethylene oxide to CMC (Oxiplex, FzioMed, San Luis Obispo, CA). Polyethylene oxide has been used because it is a substance that minimizes thrombogenesis. In a pilot study, adhesions were dramatically reduced with the application.\(^9\) The presence of blood made no impact on the rate of adhesion formation, and laparoscopic introduction of the material was not problematic.

OFC (Interceed, TC7, Ethicon, Cincinnati, OH) also has attained initial clinical success. One trial of 134 infertile patients utilized second-look laparoscopy 10 to 14 days after laparotomy for adhesiolysis.\(^9\) The application of ORC barriers significantly reduced the number of adhesions that formed with the pelvic sidewall (61\% versus 39\%). Other studies have found decreased rates of adhesion formation with ORC barriers after myomectomy\(^9\) and ovarian surgery.\(^1\) However, the efficacy of ORC is significantly reduced if hemostasis is not achieved, and the fabric nature of the product makes passage through a laparoscopic port cumbersome.\(^9\)

Haney et al\(^9\) compared ORC and ePTFE barriers in a randomized, multicenter comparison of 32 patients. Adhesion scores were gauged based on type, extent, and tenacity. At second-look laparoscopy, the adhesion scores fell substantially in both groups, although significantly more in the ePTFE group. The authors ascribed the difference to a combination of hemostasis issues and the fact that ORC is caustic to cells. However, ePTFE barriers also raise the question of permanent foreign body implantation. Some reports have suggested that removal may be accomplished safely,\(^9\) but little evidence exists to mandate that the inert barrier be removed at all.

**FUTURE DIRECTIONS**

Surgeons are realizing that adhesions and their complications are potentially avoidable. This heightened awareness will lead to new research pathways geared towards minimizing adhesions. For instance, with its increasing use by surgeons, ultrasound may find application in non-invasive assessment of adhesion formation.

As research illuminates the pathways, the technology will continue to develop in step. All of the current barrier devices are in relatively early stages of trial and development, and new materials are in evolution.\(^9\) Existing substances are being applied in novel ways, such as the recent use of surfactant as an antiadhesive agent.\(^7\) Pioneers in laparoscopy will continue to challenge our assumptions on the pathogenesis and treatment of adhesions and may ultimately lead to the elimination of adhesions as a significant cause of surgical morbidity.

**SUMMARY**

Adhesions remain a significant and under-recognized problem in the surgical community, because they are not an inevitable consequence of surgical procedures. Laparoscopy itself may reduce the incidence of adhesions relative to laparotomy. At present, no single adjuvant agent has been shown to be entirely effective in reducing postoperative adhesions. However, a number of different modalities are becoming available to the laparoscopic surgeon and include the use of barrier devices, systemic medications, and topical solutions. Continuing clinical research will help delineate which of these modalities ultimately proves best for the prevention of adhesions that develop after laparoscopic and open surgery.

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