Effects of five different barrier materials on postsurgical adhesion formation in the rat

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Post surgical adhesion formation is a significant clinical problem within every surgical specialism. Due to the problems that adhesions cause, a wide variety of adjunctive treatments to prevent the formation and reformation of adhesions have been proposed. One of the modalities that has been studied extensively and that has been showing the most promising results is the so-called barrier method. The purpose of the present study was to compare the efficacy of five of these barrier materials in the prevention of postsurgical adhesion formation in a standardized rat adhesion model. It was concluded that no beneficial effect of Ringer’s lactate on adhesion formation was seen. Significant reductions (P < 0.0001) in adhesion percentages compared to control animals were seen with Polyactive™, PRECLUDE Peritoneal Membrane™, Seprafilm™ and Tissucol™, but only PRECLUDE Peritoneal Membrane and Seprafilm significantly reduced adhesions (P < 0.01) when the barrier-treated peritoneal defects were compared with contralateral control-side peritoneal defects. The results of our study suggest that Seprafilm and PRECLUDE Peritoneal Membrane are superior to Tissucol and Polyactive in preventing adhesion formation. When Polyactive was still attached to the site of application during the second laparotomy, similar results to Seprafilm and PRECLUDE Peritoneal Membrane were seen. Future studies on the efficacy of a material to decrease adhesion formation should always include a comparison of several control materials in the same model. Our study indicates that Seprafilm or PRECLUDE Peritoneal Membrane might be used as standards of control.

Key words: adhesions/comparative study/prevention/rat model

Introduction

Post surgical adhesion formation is a significant clinical problem within every surgical specialism. Specifically after almost every intra-abdominal surgical procedure, these adhesions are a frequently ensuing complication. Bowel obstruction and/or chronic pelvic pain are common complications due to this formation of adhesions. Additionally, adhesions may cause gynaecological problems because of their interference with fertility. Several studies have reported the occurrence of postoperative intra-abdominal adhesions in 50% to 95% of women undergoing gynaecological surgery (Diamond, 1995).

Due to these problems, a wide variety of adjunctive treatments to prevent the formation and reformation of adhesions have been proposed. Most of these treatments, however, show inconsistent results. In an attempt to reduce the inflammatory reaction at the site of the peritoneal trauma, corticosteroids were used and later, the anti-adhesive properties of calcium-channel blockers and antihistamines were studied. More recent studies deal with non-steroidal anti-inflammatory drugs (NSAIDs), tissue plasminogen activator (t-PA) and selective immunosuppressors [i.e. tumour necrosis factor α (TNF-α) and interleukin-1 (IL-1) antibodies]. Various results with all these treatments have been reported (diZerega, 1994; Pijlman et al., 1994; Bakkum et al., 1996; Risberg, 1997).

One of the modalities that has been studied extensively and that has been showing the most promising results is the so-called barrier method. With the barrier technique, surgically traumatized surfaces are kept covered during mesothelial regeneration, thus preventing adherence of adjacent structures and reducing adhesion formation. Barriers consist of intra-abdominal fluids such as Hyskon™ (32% Dextran 70) and Ringer’s lactate, as well as of solid materials such as carboxymethylcellulose, Interceed™ (oxidized regenerated cellulose), Poloxamer 407™, Polyactive™ (composed of a polyethylene glycol and polybutyleneterephthalate co-polymer), PRECLUDE Peritoneal Membrane™ (expanded polytetrafluoroethylene), fibrin glue (Tissucol™) and Seprafilm™ (biodegradable membrane based on a chemically modified form of hyaluronic acid and carboxymethylcellulose). All these materials have a unique composition and characteristics with limitations and advantages for use in the clinical setting. The ideal barrier should have the following characteristics: anti-adhesive, high biocompatibility, resorbable, adherent to the traumatized surface, effective on oozing surface, applicable through the laparoscope, and not too expensive. As yet, such an ideal barrier does not exist. While for instance Hyskon is outdated as an anti-adhesion adjuvant because of the possible serious side effects such as anaphylactic shock (Trimbos Kemper and Veering, 1989), generalized coagulation problems or labial oedema, degradable Interceed and Poloxamer 407 can only be applied on dry, non-bleeding surfaces, while PRECLUDE Peritoneal Membrane is non-degradable and ideally requires a second operation for removal.

The purpose of the present study was to compare the efficacy of Polyactive, PRECLUDE Peritoneal Membrane, Ringer’s...
lactate, Seprafilm and Tissucol in the prevention of postsurgical adhesion formation in a standardized rat adhesion model and compare our results with recent literature concerning these barriers.

Materials and methods

Description of barrier materials

The Polyactive barrier (1000 Polyactive™ 60/40; Isotis, Bilthoven, The Netherlands) is composed of a polyethylene glycol and polybutyleneterephthalate co-polymer in a porous/dense bilayered mesh with a thickness of 230 µm; the barrier is resorbable and can be applied without suturing (Bakkum et al., 1995). The dense layer functions as a barrier and allows mesothelial overgrowth, while the porous layer (pore size 106–150 µm) is intended to allow ingrowth of vascularized, fibrous tissue attaching the barrier permanently.

PRECLUDE Peritoneal Membrane (W.L.Gore & Associates, b.v., ’s Hertogenbosch, The Netherlands) is a unique configuration of expanded polytetrafluoroethylene (ePTFE) that was initially used as a substitute for the pericardium (The Surgical Membrane Study Group, 1992). The barrier has a thickness of 0.1 mm, and tissue attachment is inhibited by the barrier’s extremely small pore size (<1 µm) and non-absorbable nature. It is antithrombogenic, non-reactive, easy to handle at laparotomy, maintains flexibility and limits adhesion formation between adjacent tissues.

Ringer’s lactate solution (Fresenius Kabi, ’s Hertogenbosch, The Netherlands) is an isotonic crystalloid solution that is widely used after reproductive surgery (Tulandi, 1993). Although the mechanism of action of Ringer’s lactate instillation is not clear, it is supposed that the presence of a high volume of the solution in the abdominal cavity separates raw peritoneal surfaces and thus prevents adhesion formation.

Seprafilm (Genzyme b.v., Naarden, The Netherlands) is a bioreabsorbable membrane based on a chemically modified form of hyaluronic acid and carboxymethylcellulose that is designed to reduce postoperative adhesion formation (Alponat et al., 1997). Within 24 h of application, Seprafilm turns to gel while remaining in place to separate adhesiogenic tissues during the first few days when adhesions are likely to develop, and it is cleared from the body within 28 days.

Tissucol (Immuno, b.v., Raamsdonkveer, The Netherlands) is a biological two-component glue; one component consists of 75–115 mg coagulation proteins per ml (of which 70–110 mg is fibrinogen), and the second component contains 500 IU/ml thrombin in a 40 mmol/l calcium chloride solution. Tissucol is used clinically to achieve haemostasis, to seal or glue tissue and to support wound healing. Indications include, for instance, the control of local and diffuse bleeding, the sealing of suture line bleeding, the sealing and coating of vascular protheses, and the control of haemorrhage in hepatic and splenic trauma. More recent studies suggest that Tissucol may also decrease intra-abdominal adhesion formation (de Virgilio et al., 1990).

Surgical techniques

A total of 110 female inbred Wistar rats (Harlan CPB, Zeist, The Netherlands) of reproductive age, weighing 180–200 g, was used. The rats were anaesthetized with a combination of halothane and nitrous oxide inhalation, after which the abdomen was shaved and swabbed with iodine in preparation for surgery. The surgical procedures were performed under aseptic, but not sterile, conditions. Surgical gloves were washed extensively with saline before the start of the operative procedure in order to remove any particles of powder. All surgical procedures were performed by the same researcher.

The adhesion model that we used in this study is a highly reproducible and semi-quantitative rat model for the evaluation of therapeutic modalities used for the prevention of postoperative adhesion formation, and was developed specifically for this purpose (Bakkum et al., 1994). The model consisted of bilateral excision of a parietal peritoneal defect of 1.5×1.2 cm, which was closed with three Vicryl (polyglactin 910; Ethicon, Amersfoort, The Netherlands) 5-0 sutures in 2–2 surgical knots (Holmlund, 1974). After suturing the peritoneal defect, the uterine horn was approximated to the defect by loosely suturing the uterine horn to the peritoneum both proximally and distally of the defect with two interrupted Prolene (polypropylene; Ethicon) 6-0 sutures. These Prolene sutures were placed outside of the margins of the peritoneal defect so as not to interfere with adhesion formation at the area to be scored. The uterine horn was then clamped with an artery forceps three times opposite to the three Vicryl sutures during 10 s per localization. No attempt at haemostasis was made during the procedure. Blood loss was quantified subjectively by grading the amount of blood after the excision of the defect as either mild, moderate or severe. Blood clots were removed in every animal with a moist cotton swab after the procedure had been completed. During surgery, the bowel tissues were kept moist with wet gauze in order to avoid dehydration; there was no intraperitoneal irrigation. The musculoperitoneal layer was closed evertedly with a running Vicryl 5-0 suture, and the cutaneous layer with Vicryl 3-0 sutures.

Experimental design

The 110 rats, and thus 220 peritoneal defects, were assigned randomly to six different groups; five treatment groups (Polyactive, PRECLUDE Peritoneal Membrane, Ringer’s lactate, Seprafilm and Tissucol) each consisting of 20 rats, and a control group of 10 rats. The rats were randomized after the surgical procedure had been completed. The 10 sham-operated control rats were subjected to a similar surgical procedure, but without the application of a barrier material. All the barrier materials, except for Ringer’s lactate, were assigned randomly to one peritoneal defect for unilateral application in each rat, so that each rat could also serve as its own control. Polyactive, PRECLUDE Peritoneal Membrane and Seprafilm were cut to size, measuring 18×20 mm, before application onto the peritoneal defect.

Polyactive and Seprafilm were applied without suturing, whereas PRECLUDE Peritoneal Membrane was applied to the peritoneal defect with four Gore-Tex™ (’s Hertogenbosch, The Netherlands) CV-6 sutures. A 6 ml aliquot of the Ringer’s lactate solution was deposited intraperitoneally before closure of the abdomen. Tissucol (0.1 ml) was applied to the defect by means of the Duploject-system; at 2 min after application, the peritoneal site was rinsed with 1 ml 0.9% NaCl solution, after which the fluid was removed with a pipette before abdominal closure.

Scoring of the adhesions

At 2 weeks after surgery, the rats were killed and adhesions scored and documented macroscopically according to their extent. All adhesions were scored by the same researcher. The extent of adhesion formation was quantified by dividing the peritoneal defect through the three Vicryl sutures into eight areas, each of 12.5%. An adhesion score of 100% could thus be achieved maximally (see Figure 1). The extent of adhesions was documented by drawing them onto a diagram similar to Figure 1. After the adhesions were scored and documented in all the rats, a second retrospective scoring was carried out on all the drawings in order to check for any variability in terms of scoring the adhesions. During this second scoring, the researcher was blinded to the type of treatment in the rats. Attention was also paid to the
Table I. Mean adhesion percentages of barrier-treated peritoneal defects and contralateral control-side peritoneal defects

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean adhesion (%)</th>
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<tr>
<td></td>
<td></td>
<td>Barrier-treated</td>
<td>Control side</td>
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<tr>
<td>Control animals</td>
<td>10</td>
<td>–</td>
<td>79 ± 24</td>
<td>–</td>
</tr>
<tr>
<td>Ringer’s lactate</td>
<td>20</td>
<td>79 ± 21</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Polyactive</td>
<td>20</td>
<td>75 ± 36</td>
<td>74 ± 25</td>
<td>NS</td>
</tr>
<tr>
<td>Polyactive attached()</td>
<td>9</td>
<td>40 ± 36</td>
<td>65 ± 23</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PRECLUDE</td>
<td>20</td>
<td>41 ± 34</td>
<td>66 ± 26</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Sepraflim</td>
<td>20</td>
<td>43 ± 36</td>
<td>81 ± 18</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Tissucol</td>
<td>20</td>
<td>58 ± 36</td>
<td>72 ± 26</td>
<td>0.16</td>
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Values are mean ± SD.
\(^a\)Comparison of barrier-treated peritoneal defects and contralateral control-side peritoneal defects.
\(^b\)Polyactive in place at second laparotomy.
NS = not significant.

type of the adhesions (filmy, organized or cohesive) and the percentage of uterine horn involvement.

Statistical analysis
For statistical analysis the \(\chi^2\) test and Kruskal–Wallis one-way analysis of variance (ANOVA) were used. All data were expressed as mean ± SD, and statistical significance was defined as \(P < 0.05\).

Results
There were no surgical or postoperative mortalities, and in all animals that were studied the adhesion formation was confined to the peritoneal defects. No significant differences were found between the initial scoring of the adhesions and the retrospective scoring using the drawings made of the adhesions at postoperative evaluation in each rat. Adhesion percentages referred to below are those from the initial scoring. At postoperative evaluation, the control animals that were operated on without appliance of a barrier showed an average adhesion percentage of 79 ± 24% per peritoneal defect (Table I).

There were no significant differences between mean adhesion percentages of the control-side peritoneal defects of the barrier-treated animals and those of the control animals (Table I). No significant difference was observed between the control-side peritoneal defects of the barrier-treated animals and the peritoneal defects of the control animals with respect to uterine horn involvement.

The peritoneal defects of the control animals and Ringer’s lactate-treated animals (mean adhesion percentages both 79%) had significantly more adhesions than the barrier-treated peritoneal defects of the other barrier-treated animals (\(P < 0.0001\)). Mean adhesion percentages of the barrier-treated peritoneal defects are shown in Table I. No significant difference was found between the barrier-treated peritoneal defects of these four groups of barrier-treated animals.

As shown in Table I, when comparing barrier-treated peritoneal defects with contralateral control-side peritoneal defects in the four groups of barrier-treated animals, important reductions in adhesion percentages were observed with all four barriers, but significantly only with PRECLUDE Peritoneal Membrane (\(P = 0.009\)) and Sepraflim (\(P = 0.001\)).

As shown in Table II, uterine horn involvement was significantly decreased with PRECLUDE Peritoneal Membrane (\(P = 0.0005\)), and was decreased slightly with other barriers, but not significantly.

Eleven of the 20 Polyactive barriers had detached from the peritoneal defect, and adhesion formation had occurred on most of these uncovered defects. Although the mean adhesion percentage of the defects where Polyactive was in place at the second laparotomy was lower than that of the average score of all the Polyactive barriers (40% and 57% respectively), no significant difference was found when compared with other barrier-treated peritoneal defects. The films that were detached could generally be retrieved in either the omentum, pelvic fat body or mesosalpinx of the uterine horn. Significant reductions were also seen with Polyactive that was still attached (\(n = 9\)) to the site of application during the second laparotomy.

No significant differences were found with respect to the type of adhesions formed (filmy, organized or cohesive) for the barrier-treated peritoneal defects when compared with the control-side peritoneal defects, and between the barrier-treated peritoneal defects of the five groups of barrier-treated animals. Also, no influence of mild, moderate or severe blood loss on the extent and/or type of adhesions could be established (data not shown).

Discussion
In the present study, five different barrier materials were studied for their efficacy in the prevention of postoperative mortalities.
adhesion formation in a rat adhesion model. The results demonstrate that installation of Ringer’s lactate solution has no effect on preventing adhesion formation. Earlier results in animal models of the use of Ringer’s lactate in the prevention of postoperative adhesion formation are inconsistent. It has been suggested previously (Yaacobi and Goldberg, 1991) that extensive irrigation with Ringer’s lactate in surgery must be viewed with caution. In the mouse model they used, even unabraded peritoneum formed adhesions with Ringer’s lactate irrigation, while no irrigation clearly yielded superior results. Similarly, in a study in rats (Harris et al., 1995), no beneficial effect was found following the instillation of Ringer’s lactate solution. However, others (Pagidas and Tulandi, 1992) found a significant reduction in the formation of adhesions in a study in rats with the use of intraperitoneal Ringer’s lactate, and its efficacy was superior to that of Interceed, Gore-Tex and amniotic membrane. They concluded that, apart from the anti-adhesive properties, other advantages of Ringer’s lactate are that it is inexpensive, readily available, and has minimal side effects. Other animal studies also reported a benefit from Ringer’s lactate in preventing adhesions (Caballero and Tulandi, 1992; Tulandi, 1993). However, clinical data on the use of Ringer’s lactate show no beneficial effect. In two clinical studies, the effect of Dextran solution on postoperative adhesion formation was compared with that of Ringer’s lactate solution (Rosenburg and Board, 1984; Jansen, 1985). In both studies, no beneficial effect of the Ringer’s lactate was found, and many of the patients treated with Ringer’s lactate had more adhesions at the time of second-look laparoscopy than before the initial procedure.

The results obtained with Polyactive were somewhat disappointing. Although there were no significant differences between Polyactive, Seprafilm, PRECLUDE Peritoneal Membrane and Tissucol when compared with control and Ringer’s lactate-treated animals, 11 of the 20 barriers detached from the site of application. In a previous study (Bakkum et al., 1995), Polyactive was found to be efficacious in the prevention of postoperative adhesion formation in the same rat uterine horn model, and although also in that study 50% of the barriers had detached from the site of application (in contrast to our results), a much lower mean adhesion percentage was found for the barriers that were in place at second laparotomy. Initial clinical results with the Polyactive barrier in patients undergoing myomectomy are promising, although further investigation is needed to achieve better initial adherence at the original application site of this new, degradable barrier.

After the initial use of PRECLUDE Peritoneal Membrane as a passive biological membrane substitute (pericardium and peritoneum), it was also found to be an effective barrier for adhesion prevention in most of the animal studies conducted in mice, rats, rabbits and monkeys (Goldberg et al., 1987; Boyers et al., 1988; Montz et al., 1992; Pagidas and Tulandi, 1992; Haney and Doty, 1993; Grow et al., 1994; Harris et al., 1995). Also, in the present study PRECLUDE Peritoneal Membrane was found to be effective in the prevention of postoperative adhesions when compared with control and Ringer’s lactate-treated animals. Although no significant difference was found between the barrier-treated peritoneal defects of the four groups of barrier-treated animals, the PRECLUDE Peritoneal Membrane-treated animals had the lowest adhesion percentage (41%), and when comparing barrier-treated peritoneal defects with contralateral control-side peritoneal defects, significant reductions were seen only with PRECLUDE Peritoneal Membrane \( P = 0.009 \) and Seprafilm \( P = 0.001 \). Also, a significant decrease in uterine horn involvement was found only in this group; only two of the 20 animals had involvement of the uterine horn \( P = 0.0005 \). The latter finding was probably due to the non-degradable character of this barrier material, preventing the uterine horn from coming into contact with the peritoneal defect and most of the pelvic fat body. Most of the adhesions that did form were found in areas of wrinkles or at margins of the barrier due to the small size of the barrier \((18 \times 20 \text{ mm})\) in relation to the size of the peritoneal defect \((15 \times 12 \text{ mm})\).

In several clinical studies, PRECLUDE Peritoneal Membrane has also been shown to be efficacious in the prevention of postoperative adhesion formation. One multicentre clinical study examined the efficacy of PRECLUDE Peritoneal Membrane in the reduction of peritoneal adhesion formation and reformation after treatment for moderate to severe pelvic adhesive disease, significant deperitonealization or myomectomy (The Surgical Membrane Study Group, 1992). At second-look laparoscopy, in all patient groups a significant reduction in adhesion formation and reformation was found compared with uncovered control sites. In a second study, the efficacy of PRECLUDE Peritoneal Membrane was compared with Interceed in a multicentre, non-blinded, randomized trial in patients having bilateral pelvic sidewall adhesions undergoing reconstructive surgery and second-look laparoscopy in which each barrier was allocated randomly to the left or right sidewall of every patient (Haney et al., 1995). PRECLUDE Peritoneal Membrane was associated with fewer adhesions to the pelvic sidewall than Interceed. The effect of PRECLUDE Peritoneal Membrane was also evaluated in reducing postmyomectomy adhesion formation (The Myomectomy Adhesion Multicenter Study Group, 1995). In 27 patients having myomectomy with at least two incisions on the uterine fundus and posterior uterine wall of similar length, the two incision sites were randomly assigned to be covered with PRECLUDE Peritoneal Membrane, or were left uncovered. At second-look laparoscopy, 15 of 27 incisions covered with PRECLUDE Peritoneal Membrane \((55.6\%)\) and only two of 27 uncovered sites \((7.4\%)\) were completely free of adhesions, and the mean adhesion score at the PRECLUDE Peritoneal Membrane™ was significantly lower than at the control sites. Although efficacious in these clinical studies, important drawbacks of this barrier were that it must be sutured in place, which makes it difficult and time-consuming to apply—especially laparoscopically—and that it must be removed in a second procedure, because of its non-degradable character.

The Seprafilm barrier has significantly reduced the incidence, extent and severity of postoperative adhesions in a variety of animal models (Alponat et al., 1997; Burns et al., 1997), and also in two large, prospective, randomized controlled, multicentre clinical studies. One of these studies involved gynaecological surgery using myomectomy in which patients...
randomly received Seprafilm wrapped over the entire uterus, or no treatment (Diamond, 1995). The other study involved general surgery where patients undergoing colectomy and ileal pouch–anal anastomosis with diverting loop ileostomy randomly did, or did not, receive Seprafilm placed under the midline incision prior to closure of the abdomen (Becker et al., 1996). In both trials, Seprafilm significantly reduced postoperative adhesion development. In the present study, Seprafilm significantly reduced adhesion formation to 43% compared with 79% in both control and Ringer’s lactate-treated animals, and also when comparing barrier-treated peritoneal defects with contralateral control-side peritoneal defects ($P = 0.001$).

The role of Tissucol in the formation of adhesions only became the subject of study more recently. According to the traditional model of adhesion formation—that fibrin serves as a matrix for ingrowth of fibroblasts with their subsequent elaboration of collagen—Tissucol seemed to have the potential for markedly increasing adhesion formation. However, several studies in rats and rabbits where peritoneal defects were treated with Tissucol showed a significant decrease in intra-abdominal adhesion formation and reformation (de Virgilio et al., 1990; Koltai and Gerhard, 1990; Caballero and Tulandi, 1992; Sheppard et al., 1993; de Iaco et al., 1994; Evrard et al., 1995). Other investigators have not reported good results with Tissucol as an adhesion prevention method. In two of these studies, Tissucol was tested on peritoneal defects in the rat (Gauwerky et al., 1990; Harris et al., 1995), while two other studies tested Tissucol in rat colonic (van der Ham et al., 1991) and rabbit Fallopian tube anastomoses (Dargenio et al., 1986). In the present study, the peritoneal defects that were treated with Tissucol showed a significant decrease in adhesion formation compared with control and Ringer’s lactate-treated animals, but no significant difference was found when the Tissucol-treated defects were compared with the contralateral control-side peritoneal defects.

Clinical data on the use of Tissucol in adhesion prevention is scarce. In a previous study (Larsson et al., 1991), the benefits of Tissucol were evaluated in patients undergoing salpingostomy combined with salpingolysis and ovariolysis, and injured serosa was covered with Tissucol. At postoperative laparoscopy, formation of adhesions was significantly prevented when denuded serosa was covered with Tissucol. The preventive effect was explained by the inhibition of further exudation of fibrin, and by mechanical properties of the coagulated fibrin sealant. This reduction in adhesion formation was not found in patients undergoing tubal anastomosis (Tulandi, 1991). The effect of fibrin glue on the formation of adhesions after laparoscopic excision of endometriomas was also evaluated (Takeuchi et al., 1996). Ten patients underwent laparoscopic resection of endometriomas leaving the ovarian capsule open, and 20 patients underwent laparoscopic removal of endometriomas and fibrin glue approximation of the ovarian capsule, as well as coating of serosal defects with the glue. At second-look laparoscopy, the mean adnexal adhesion score in patients without fibrin glue increased slightly, while in patients treated with fibrin glue the score was decreased significantly.

It can be concluded that the adhesion model we used in the present study was very consistent in producing adhesions. Furthermore, no beneficial effect of Ringer’s lactate on adhesion formation was seen. Significant reductions in adhesion percentages compared with control animals were seen with Polyactive, PRECLUDE Peritoneal Membrane, Seprafilm and Tissucol, but only PRECLUDE Peritoneal Membrane and Seprafilm significantly reduced adhesions when the barrier-treated peritoneal defects were compared with contralateral control-side peritoneal defects. Thus, the results of our study suggest that Seprafilm and PRECLUDE Peritoneal Membrane are superior to Tissucol and Polyactive in preventing adhesion formation. Future studies on the efficacy of a material to decrease adhesion formation should always include a comparison of several control materials in the same model. Our study indicates that Seprafilm or PRECLUDE Peritoneal Membrane might be used as standards of control.

References
Prevention of postsurgical adhesion formation


Received on October 21, 1999; accepted on March 31, 2000