

## Intraabdominal mesh prosthesis in a canine model

B. Schlechter, J. Marks, R. B. Shillingstad, J. L. Ponsky

Department of Surgery, Mount Sinai Medical Center, Cleveland, OH 44139, USA

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**Abstract.** Laparoscopic inguinal hernia repair is still at an investigational stage, and varying methods have been described in the literature. These include the transabdominal preperitoneal approach, the intraperitoneal onlay mesh procedure, and the extraperitoneal approach. This study evaluates the differences in macroscopic adhesion formation between transabdominal preperitoneal mesh placement, intraperitoneal onlay mesh procedures, and extraperitoneal mesh placement in a canine model. The determination of microscopic tissue ingrowth and mesh incorporation was not a goal of this study. Operative sites utilizing mesh in a re-peritonealized fashion resulted in less adhesion formation than did those sites where mesh was placed in an intraperitoneal manner using the onlay technique. Mesh placed in the extraperitoneal space without entering the peritoneal cavity did not exhibit any adhesion formation. Results favor the re-peritonealization of intraabdominal mesh or mesh placement by an extraperitoneal approach.

**Key words:** Laparoscopic herniorrhaphy – Prolene mesh – Adhesion formation

Laparoscopic herniorrhaphy has been investigated as an alternative to traditional hernia repairs. Early reports suggest that the procedure is safe and effective. The median follow-up in the most recent multicentered trial is too short to observe the long-term complications, and the potential for adhesion formation and resultant small-bowel obstruction is a concern. Whether the risk is increased when a foreign body is left exposed to intraperitoneal contents, rather than being in a re-peritonealized space, is not clear.

Six dogs were laparoscopically evaluated using

standard techniques and those with preexisting adhesions were excluded. Prolene mesh (2.5 × 5 cm) was secured in the right pelvis using an endoscopic stapler (Ethicon Inc.). A second segment of mesh was placed into a preperitoneal pocket in the left pelvis, and this was then re-peritonealized. A third piece was placed into an extraperitoneal space in the anterior abdominal wall. The dogs were sacrificed at 6 weeks and adhesion formation was evaluated. The authors hypothesized that Prolene mesh placed in an intraperitoneal fashion would result in increased adhesion formation.

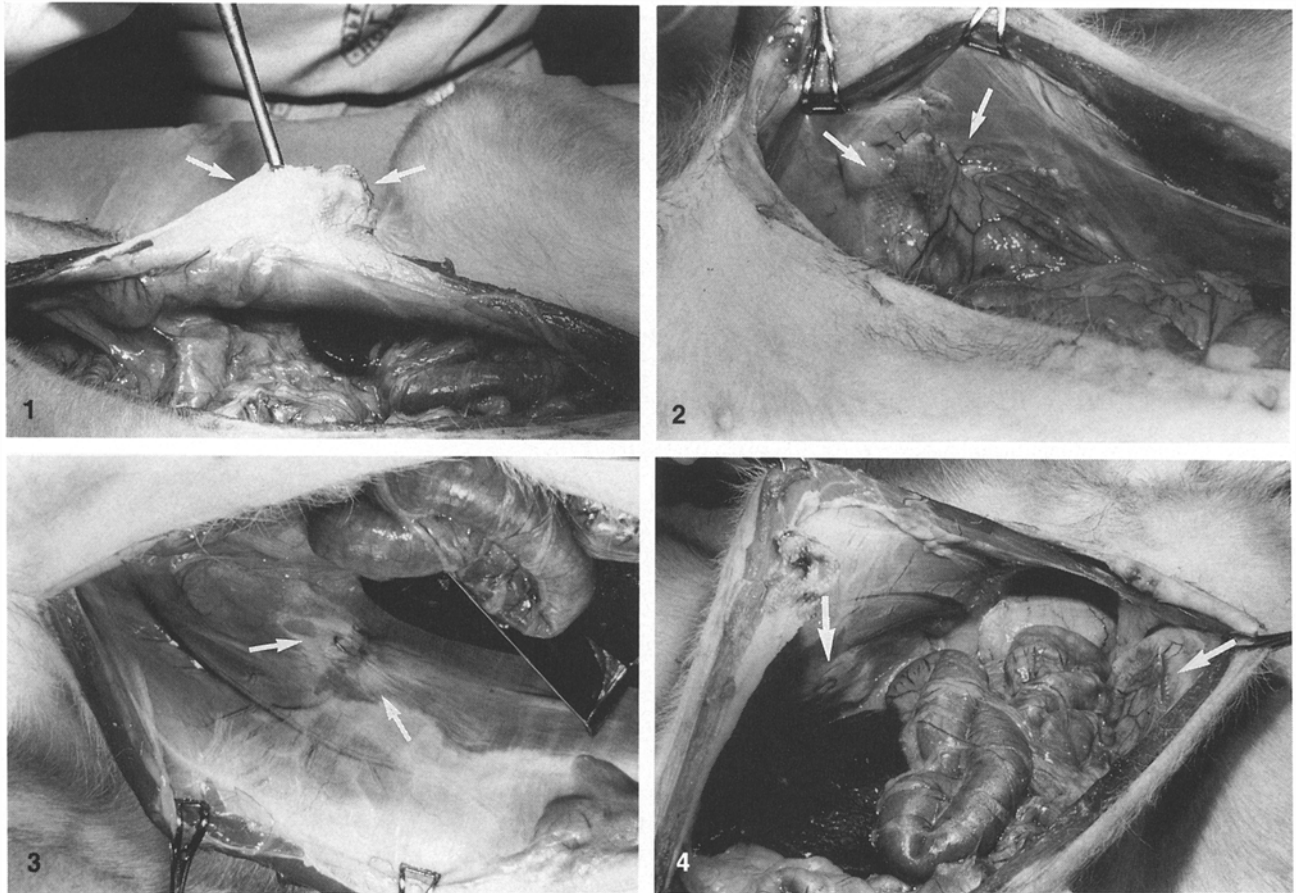
### Materials and methods

This study was conducted under the auspices and with the approval of the Animal Research Committee of the Mount Sinai Medical Center, Cleveland, Ohio. Adult Mongrel dogs weighing 16–24 kg were used. All animals underwent laparoscopy following routine pre-paration, premedication with subcutaneous atropine (0.04 mg/kg (and acepromazine (2.5 mg), and general anesthesia with intravenous sodium pentobarbital (15 mg/kg). A total of six dogs underwent laparoscopy so previous adhesion formation could be assessed. Following documentation of an absence of adhesion formation, each dog underwent placement of Prolene mesh (2.5 × 5.0 cm). The mesh was placed in each dog in three different ways with each dog serving as its own control. Prolene mesh was secured in onlay fashion in the right pelvis using an endoscopic stapler (Ethicon Inc.). A second segment of equal-size mesh was placed laparoscopically into a preperitoneal pocket in the left pelvis and was re-peritonealized utilizing endoscopic staples for the closure. A third piece of mesh was placed using an open technique into an extraperitoneal space in the anterior abdominal wall. Upon removal of the laparoscope all wounds were closed with 4-0 prolene suture in a simple interrupted fashion.

The dogs were fed a regular chow diet. After 6 weeks each dog underwent exploratory laparotomy following euthanasia with a pentobarbital-based euthanasic (Socumb; Butler Corporation, Columbus, OH). The abdominal cavity was assessed for adhesion formation and the various techniques were compared.

### Results

All six dogs survived the 6-week postoperative period without evidence of infection or small-bowel obstruction. Reexploration of each dog was performed through



**Fig. 1.** Prolene mesh placed in an extraperitoneal fashion (arrows)

**Fig. 2.** Reperitonealized Prolene mesh placed laparoscopically. Note absence of adhesion formation (arrows)

**Fig. 3.** Prolene mesh placed as an onlay patch. Note the abundance of dense adhesions (arrows)

**Fig. 4.** Prolene mesh placed in a reperitonealized fashion (right arrow) vs the onlay technique (left arrow)

a lower abdominal transverse incision, avoiding the site of extraperitoneal mesh. The three sites of mesh placement were evaluated for adhesion formation. Intraabdominally there was no evidence of infection or small-bowel obstruction, and the mesh was adherent to its site of placement in all cases.

In all six dogs the extraperitoneal sites had no omental or small-bowel adhesions. The skin sites were well healed and the mesh was encased in fibrous scar. The peritoneum was without obvious abnormalities (Fig. 1).

The intraperitoneal onlay technique resulted in dense adhesion formation in all six dogs. Both small bowel and omentum were adherent to the mesh. There was no evidence of small-bowel fistula formation or small-bowel obstruction (Fig. 2).

The transabdominal preperitoneal technique resulted in adhesion formation in only two of the six dogs. Again no small-bowel fistulas were noted. The other four dogs had surgical sites which were well healed and which had no evidence of adhesion formation. In these dogs, the mesh was visible beneath the

overlying peritoneum (Fig. 3), and the peritoneum was not thickened (Fig. 4).

## Discussion

Laparoscopy has long been appreciated by the gynecologic surgeon as a valuable tool for diagnostic and therapeutic procedures. Many general surgical procedures which had been performed in a traditional fashion are now being attempted laparoscopically. An example of this is the recent investigation in laparoscopic herniorrhaphy. Various methods have been proposed in the literature to repair hernias laparoscopically. These include a transabdominal preperitoneal approach, an extraperitoneal approach, and an intraperitoneal onlay mesh technique. Although no procedure is without risk, obvious potential long-term complications of laparoscopic herniorrhaphy have been cited. Salerno and Fitzgibbons documented the occurrence of adhesion formation in the pig model during early studies utilizing

the intraperitoneal onlay mesh technique [4]. Our study was designed to evaluate the incidence of adhesion formation in the proposed techniques for laparoscopic hernia repair.

Small-bowel adhesion formation was encountered most frequently in the areas with exposed intraperitoneal mesh. Placement of mesh in an extraperitoneal space or in a re-peritonealized pocket led to less adhesion formation. These findings can then be extrapolated to the respective laparoscopic herniorrhaphy techniques. Adhesion formation in the human model has been shown to occur within 24 h. In the dog model fibrin sheath formation around a foreign body has been shown to occur within 1 week [3]. A time period of 6 weeks was chosen arbitrarily for this study to allow for small-bowel or omental adhesion formation. It can be proposed that exposed intraperitoneal mesh as in the intraperitoneal onlay mesh technique would therefore lead to increased adhesion formation. Whether this would directly lead to increased incidence of small bowel obstruction or fistula formation can only be speculated upon.

Intraperitoneal mesh placement has been used in other procedures including vertical banded gastroplasty and Ripstein rectopexy, and the mesh has been used as a pelvic sling in patients undergoing the Miles' procedure. The actual incidence of small-bowel obstruction in these cases has not been proven to be increased; however, mesh placed as a pelvic sling in most cases in recent years has been absorbable. This may account for a lower complication rate.

Laboratory studies have shown that mesh placement has been associated with chronic inflammatory reaction and fibrosis, as well as increased tissue edema and blood flow [1, 2]. The inflammatory response to mesh in direct contact with muscle leads to increased early blood flow, and it is suggested that mesh implants should be placed in apposition to muscles to obtain well-vascularized healing. Mesh placed directly on the peritoneum lacked early blood flow and may be associ-

ated with poorer healing [1]. The inflammatory response characterized by macrophage migration, however, was found to be similar when mesh was placed in the peritoneum and when it was placed between muscle layers [1]. In a study comparing synthetic meshes, the chronic inflammatory reaction and associated fibrosis was found to be greater in subjects utilizing Marlex mesh, a synthetic material similar to Prolene mesh, than those using Gore-Tex [5]. Further studies are necessary to determine whether the various inflammatory reactions of these synthetic materials are associated with different rates of adhesion formation in a clinical model.

The results of our study indicate that preperitoneal and extraperitoneal mesh placement may result in diminished adhesion formation in the canine model. The authors recognize that this study involved a small number of subjects, which may lead to increased result bias. Also, it is unclear whether adhesion formation at 6 weeks in a canine model is truly representative of that in humans. Further prospective trials, comparing the different laparoscopic hernia repair techniques in the human population, are needed to truly assess the potential long-term complications of this experimental procedure.

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