Routine use of bioprosthetic mesh is not necessary: A retrospective review of 100 consecutive cases of intra-abdominal midweight polypropylene mesh for ventral hernia repair

Jason M. Souza, MD, and Gregory A. Dumanian, MD, FACS, Chicago, IL

Background. The Ventral Hernia Working Group (VHWG) recently proposed a grading system to assist surgeons in selecting the appropriate mesh based on an individual patient’s risk of developing a postoperative complication. The VHWG grading scale was used to evaluate the incidence of surgical-site complications in 100 consecutive midline ventral hernias repaired with uncoated mid-weight polypropylene mesh.

Methods. A retrospective review was conducted of 100 consecutive cases of midline ventral hernia repair using an intra-abdominal mesh underlay between July 2005 and May 2010. The median duration of follow-up was 23 months.

Results. Using the VHWG scale, 50 percent of cases were considered Grade 2 (“Co-morbid”) and 28 percent considered Grade 3 (“Potentially Contaminated”). The remaining cases were Grade 1 (“Low-risk”). Overall, there was a 5.6 percent rate of hernia recurrence, with a mean time to recurrence of 17 months. There were no enterocutaneous fistulae or infections requiring mesh removal.

Conclusion. The use of uncoated mid-weight polypropylene mesh for reinforcement of midline ventral hernia repairs was not associated with increased rates of infection, fistula formation, or clinically significant adhesions. These findings challenge the recommendation by the VHWG to avoid synthetic repair material in patients with comorbidities or in “potentially contaminated” fields. (Surgery 2013;153:393-9.)

From the Northwestern University, Feinberg School of Medicine, Division of Plastic and Reconstructive Surgery, Chicago, IL

Following the first randomized, controlled trial in which investigators compared suture with mesh in the repair of incisional hernias, mesh reinforcement has become an accepted facet of the operative management of incisional hernias. Recent improvements in synthetic mesh and the development of bioprosthetic mesh have led to a bewildering number of studies comparing 1 product with its competitor. In response to an absence of high-level evidence, the Ventral Hernia Working Group (VHWG) was established in 2008 to review the literature on hernia repair and develop evidence-based recommendations regarding the preferred technique and material to be used for incisional hernia repair.1 The VHWG developed widely quoted recommendations regarding mesh selection by using a 4-tier grading scale to stratify patients based on their risk of developing postoperative complications. Using this instrument, the VHWG suggests an advantage in the use of bioprosthetic mesh for all but low-risk patients and recommends against the use of synthetic material because of concerns for increased rates of infection, adhesions, enterocutaneous fistulae, and anticipated difficulty during a secondary operation.
Motivated by high rates of recurrence after bioprosthetic repair, our standard approach to incisional hernias has evolved from reinforcement with bioprosthetic mesh to a supported repair that employs an intraperitoneal underlay of uncoated midweight polypropylene mesh. It was our clinical impression that this technique has provided durable repairs and has not been associated with the complications frequently attributed to intra-abdominal placement of uncoated synthetic mesh. In light of the discrepancy between the VHWG recommendations and our clinical impression, we performed a retrospective review of 100 consecutive midline cases of incisional hernia repair using uncoated midweight polypropylene over the last 5 years, with a specific emphasis on complications based on VHWG grade.

METHODS

A comprehensive retrospective medical record review was performed of 100 consecutive cases of direct or components separation hernia repair in which surgeons used an intraperitoneal underlay of uncoated midweight polypropylene mesh (Soft Prolene, Ethicon, Inc, Somerville, NJ) for “pure” midline abdominal wall hernias. Patients with multiple hernia defects, bridged repairs, bioprosthetic or alternative synthetic mesh repairs, or polypropylene mesh repairs whereby the mesh was not placed intra-abdominally were all excluded from analysis. All VHWG grade 4 patients also were excluded because they are repaired with a biologic mesh or in a staged fashion.

All cases were performed by a single surgeon (G.A.D.) at Northwestern Memorial Hospital in Chicago, Illinois, between October 2005 and June 2010. For all of the patients, the medial aspects of the rectus abdominis muscles were approximated in the midline, with the mesh serving to support the repaired linea alba. The 100 consecutive cases were performed in 98 different patients, with 2 patients requiring repair of a second midline hernia within the study period. The first patient developed a recurrence at the initial hernia repair site, and the second developed a new hernia at a midline location that was remote from the initial hernia repair site.

Of the 98 patients, patient characteristics including age, body mass index (BMI), medical comorbidities, number of previous abdominal operations, hernia size, operative details, and postoperative results were examined. Follow-up data were obtained from analysis of the surgeon’s office records, the patient’s hospital and outpatient electronic medical records, and preoperative abdominal computed tomography (CT) findings. If the results of a recent abdominal examination could not be obtained from the medical record (21 patients), the patient was contacted and administered a standardized telephone survey (14 patients) or returned to clinic for follow-up examination (7 patients). The length of follow-up was defined to be from the date of procedure to the last direct patient contact or CT scan. To facilitate analysis, patients were assigned a Ventral Hernia Working Group grade on the basis of the presence of comorbidities thought to be risk factors for developing an operative-site complication. The Institutional Review Board of Northwestern University approved this study.

Assessment of hernia size. Preoperative hernia size was measured using digital measurement tools from standard CT scans of the abdomen and pelvis. The scans were performed at the discretion of the senior author. Preoperative imaging is not essential for all hernia repairs but was used in select cases to identify potential intra-abdominal processes and to assist in operative planning of complex abdominal wall repairs. Using digital measurement tools, we recorded the widest separation of the medial aspect of the rectus muscles for each patient who underwent preoperative CT. Preoperative imaging was available for 56 of 89 (63%) cases included in the final analysis. For cases lacking preoperative imaging, no attempt was made to include an intraoperative estimation of hernia size in the final analysis, as intraoperative assessments are difficult to standardize and allow for significant surgeon bias.

Operative technique. The following approach is used to electively repair midline ventral hernias. Alternative materials and techniques are used in the setting of gross contamination or when a fresh bowel anastomosis lies adjacent to the mesh. With the patient under general anesthesia, the hernia is approached through a midline incision that is typically longer than the original midline incision. Bowel is widely dissected free from the undersurface of the hernia sac and the entire peritoneal surface of the anterior abdominal wall. A combination of electrocautery and blunt dissection is used to locate the medial aspect of the rectus muscles. Once identified, further dissection is used to expose 4 cm of the superficial surface of the muscles bilaterally for the length of the midline incision. At this point, tension is applied to the rectus muscles to ascertain if they can be reapproximated in the midline. The likelihood of reapproximating the rectus muscles without further release depends on the original size of the defect, previous weight loss, prior pregnancy, and
the age of the hernia, all of which factor into the compliance of the lateral abdominal wall.

If the rectus muscles come together in the midline, they are reinforced with a 7.5-cm-wide underlay of uncoated midweight polypropylene mesh with the technique to be described. If the rectus muscles cannot be reapproximated without undue tension, then a components separation is performed. Bilaterally, the external oblique is released anteriorly through a 6-cm transverse subcostal incision. As previously described, these transverse incisions allow full release of the attachment between the external oblique and anterior rectus sheath via bluntly dissected tunnels located over the semilunar lines. These tunnels extend from above the costal margin to the anterior superior iliac spine and are ultimately completed via small inferior connections with the midline incision. Importantly, this approach preserves the umbilical cutaneous perforators that run from the rectus muscle to the overlying skin.

In all but the most challenging defects, this anterior component separation will enable transposition of the rectus muscles into a midline position. With the muscles now able to be approximated, a 7.5-cm piece of uncoated midweight polypropylene mesh is positioned along the length of the incision and is sutured in place from superior to inferior. The mesh is secured in an intra-abdominal underlay position, with no attempt to mobilize the preperitoneal fat or the peritoneum as an interposition layer. The mesh is sutured in place using interrupted 0 polypropylene sutures that travel from the lateral extent of the superficial rectus dissection (4 cm from the medial aspect of the rectus muscles) to the edge of the mesh. When placing the suture, an effort should be made to include only a small amount of mesh within the bite to prevent wrinkling of the mesh within the suture. Sutures are placed less than 2 cm from each other along the length of the repair and they are tied down under direct vision. With the mesh being slightly narrower (7.5 cm) than the horizontal distance between sutures (4 cm × 2 = 8 cm), the medial aspect of the rectus muscles fall together in the midline and are easily approximated with 0 polypropylene sutures as a third vertical suture line. The mesh thus serves as a pledge that bears much of the tension of the hernia repair, while the newly approximated rectus muscles provide an additional layer of well-vascularized coverage for the mesh.

After closure of the rectus muscles over the mesh, all of the scarred hernia sac and much of the now-redundant midline skin is excised, serving to remove the most ischemic skin and to limit the amount of subcutaneous dead space. Before superficial closure, 1 to 3 drains are positioned superficial to the rectus muscles. Quilting sutures may also be placed between the skin and abdominal wall to further prevent seroma formation. The drains are removed when the patient has resumed normal activity and output is less than 30 mL/day.

**RESULTS**

Of the 98 patients in whom the 100 consecutive midline repairs were performed, 11 patients had insufficient follow-up (<6 months) to warrant inclusion in the final analysis. The characteristics of the excluded patients were comparable with those included in the analysis in terms of sex, age, average BMI, percent with prior recurrence, number of previous abdominal operations, and distribution of medical comorbidities. Diabetes was significantly more prevalent in the patients lost to follow-up. Patient characteristics are summarized in Table. Of the 87 patients included in the final analysis, the majority of patients were male (55%). The mean patient age was 56.8 years. Twenty-three of the 87 patients (26.4%) included in the final analysis had a BMI > 35, yielding a mean BMI of 32.1 kg/m² for the group. Forty-three patients (49.4%) underwent repair of a recurrent incisional hernia, which required removal of previously placed mesh in 19 patients (21.8%). Most patients had a history of multiple previous abdominal operations, having undergone a mean of 2.5 abdominal operations before the index hernia repair. Fifty-one of the cases (52.3%) involved components separation supported by a polypropylene underlay, whereas there were 38 cases (41.3%) of direct supported repair with polypropylene mesh. The 56 patients with preoperative CT scans demonstrated hernia defects ranging from 3.6 to 19.7 cm (mean, 9.7 cm) in transverse dimension. Fifteen patients (17.2%) were smokers, 16 (18.4%) were diabetic, 6 (6.9%) were immunosuppressed or on steroids, and 12 patients (13.8%) underwent concomitant elective bowel operation, including 2 ostomy takedown procedures. In terms of patient distribution based on WHWG grade, 44 patients (50.6%) were considered Grade 2 (“Co-Morbid”) and 24 patients (27.6%) were deemed Grade 3 (“Potentially Contaminated”). The remaining 19 patients (21.8%) were considered Grade 1 (“Low Risk”). There were no Grade 4 patients, as elective hernia repair is deferred in these patients. Figure demonstrates the distribution of cases on the basis of VHWG grade and the justification for VHWG grade on the basis of comorbidities or case characteristics.
During a median follow-up period of 23 months (range, 6–64), hernia recurrence was observed in 5 patients, yielding a hernia recurrence rate of 5.6% for the series. The mean time to recurrence was 17 months (range, 9–35). The only major complication was a case that required reoperation in the immediate postoperative period for drainage of a hematoma in a patient who had been continuously anticoagulated for a cardiac indication. Minor complications (n = 9, 10.1%) included 2 cases of cellulitis, 1 seroma that required aspiration, 3 conservatively managed hematomas, and 3 cases of minor skin sloughing or superficial wound breakdown treated in the office. Both patients with cellulitis responded to oral antibiotic therapy, and neither required operative drainage.

Of note, there were no enterocutaneous fistulae or infections requiring mesh removal. Two patients were admitted for abdominal pain thought possibly attributable to mesh-induced adhesions, one at 6 months postoperatively and the other almost 2 years after the hernia repair. Both patients successfully were managed nonoperatively with early resolution of their symptoms. Given the history of multiple previous abdominal operations in both patients, and the radiographic demonstration of a possible intestinal transition point remote from the mesh in one of the patients, it is difficult to implicate mesh-induced adhesions as the definitive cause for readmission.

**DISCUSSION**

A nihilistic view surrounding the use of synthetic mesh in open hernia repairs has developed over the years. The negative mystique surrounding synthetic mesh crystallized with the recommendations of the VHWG. Using a combination of expert opinion and literature review, the VHWG put forth a grading system that favors the use of bioprosthetic mesh over synthetic mesh in all but the most straightforward of hernias in the healthiest of patients. However, the VHWG grading scale has yet to be clinically vetted. In fact, it has already been demonstrated to have poor predictive value in the laparoscopic setting.2 This review of 100 consecutive open cases illustrates that synthetic mesh can be used effectively in ventral hernia repair, with acceptable rates shown here of both early and late complications. Given that the VHWG grading scale would have favored the use of

<table>
<thead>
<tr>
<th>Variable</th>
<th>Midline hernia repairs (n = 87)</th>
<th>Excluded/lost to follow-up (n = 11)</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline patient characteristics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sex, n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>48 (55)</td>
<td>5 (45)</td>
<td>.5448</td>
</tr>
<tr>
<td>Female</td>
<td>39 (45)</td>
<td>6 (55)</td>
<td></td>
</tr>
<tr>
<td>Age, yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean (range)</td>
<td>56.8 (38–74)</td>
<td>56.6 (43–79)</td>
<td>.9948</td>
</tr>
<tr>
<td>SD</td>
<td>12.3</td>
<td>14.2</td>
<td></td>
</tr>
<tr>
<td>Hernia size, cm</td>
<td></td>
<td></td>
<td>.1313</td>
</tr>
<tr>
<td>No. of cases in which size was measured</td>
<td>56</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Mean (range)</td>
<td>9.7 (3.6–19.7)</td>
<td>7.85 (4.0–11.0)</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>3.8</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>Body mass index, kg/m²</td>
<td></td>
<td></td>
<td>.0877</td>
</tr>
<tr>
<td>Mean (range)</td>
<td>32.1 (18.5–49.8)</td>
<td>35.7 (31.0–49.9)</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>7.0</td>
<td>6.1</td>
<td></td>
</tr>
<tr>
<td>Components separation, n (%)</td>
<td></td>
<td></td>
<td>.8694</td>
</tr>
<tr>
<td>Direct repair, n (%)</td>
<td></td>
<td></td>
<td>.8694</td>
</tr>
<tr>
<td>Previous repair, n (%)</td>
<td></td>
<td></td>
<td>.8140</td>
</tr>
<tr>
<td>Smoking, n (%)</td>
<td></td>
<td></td>
<td>.9169</td>
</tr>
<tr>
<td>Diabetes, n (%)</td>
<td></td>
<td></td>
<td>.0016†</td>
</tr>
<tr>
<td>Steroids/immunosuppression, n (%)</td>
<td></td>
<td></td>
<td>.7858</td>
</tr>
<tr>
<td>Simultaneous bowel procedure, n (%)</td>
<td></td>
<td></td>
<td>.1808</td>
</tr>
<tr>
<td>Ventrail Hernia Working Group Grade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 1 (Low Risk), n (%)</td>
<td>19 (22)</td>
<td>1 (9)</td>
<td>.3013</td>
</tr>
<tr>
<td>Grade 2 (Co-morbid), n (%)</td>
<td>44 (50)</td>
<td>9 (82)</td>
<td>.0348†</td>
</tr>
<tr>
<td>Grade 3 (Potentially Contaminated), n (%)</td>
<td>24 (28)</td>
<td>1 (9)</td>
<td>.1625</td>
</tr>
<tr>
<td>Grade 4 (Infected), n (%)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td></td>
</tr>
</tbody>
</table>

*χ² test, Student t test.
†Significant.
bioprosthetic mesh in the majority (78%) of patients in this series, this experience also directly challenges the recommendations to avoid synthetic mesh in favor of bioprosthetic material in “co-morbid” patients (Grade 2) and in “potentially contaminated” cases (Grade 3).

We attribute the successful use of synthetic mesh to our technique of abdominal wall repair. While mindful of patient factors, our technique emphasizes a physiologic view of tension and compliance and a heightened appreciation for the importance of a well-vascularized soft tissue envelope. Much of our approach is borrowed from orthopedics. Like a fracture, adequate healing of the repaired midline requires a combination of robust perfusion and appropriate stress across the repair site. Pulsatile flow found in healthy tissue has been shown to permit wound healing, whereas the laminar blood flow found in scar tissue does not. All scar tissue is aggressively excised, yielding a larger defect, but one that still permits midline closure when combined with a components release. Wide undermining of skin flaps is avoided with the specific aim of maintaining pulsatile blood flow to the overlying skin. As described, the components release is therefore performed through lateral incisions, allowing for preservation of the periumbilical perforators. The mesh is located deep to the well-vascularized rectus muscles, thereby protecting the foreign material in the event of superficial wound dehiscence. Our experience suggests that preservation of wound perfusion plays a more critical role in preventing infection and wound-related complications than any specific emphasis on antibiotic regimens, adhesive drapes, or preoperative patient “optimization.”

The low incidence of mesh-related complications in this series is better explained by the way in which the mesh was used, than by the inherent properties of the material. That said, the choice of mesh material certainly plays a role. We prefer an uncoated, midweight, macroporous mesh for its handling characteristics, ability to integrate, and supportive preclinical data. Likewise, the use of uncoated mesh avoids the proinflammatory burst that accompanies degradation of absorbable coatings.

From a technique standpoint, we don’t view the mesh as a patch or spanning sheet that is designed to relieve tension across the repair. Instead, we use it to reinforce the midline repair as a load-sharing pledget. Used in this way, only a narrow strip of mesh is implanted, decreasing the amount of foreign material that may serve as a nidus for infection or adhesion formation.

The narrow strip of mesh better approximates the contour of the abdominal midline, thus avoiding the wrinkling that occurs when a flat piece of mesh is attempted to be fit to the curved underside of the anterior abdominal wall. The use of a macroporous mesh (pore diameter greater than 1 mm) prevents the formation of a plate-like scar, which can also cause wrinkling of the mesh during scar contraction. In our experience with reoperative mesh surgery, the greatest adhesions occur at
sites of folds and other contour irregularities in the mesh. This is supported by the findings of Schreinemacher et al., where adhesions were demonstrated to be most tenacious where the tacking sutures had caused depressions in an otherwise bare sheet of intraperitoneal polypropylene mesh.

Finally, the mesh is firmly secured to the rectus muscle complex. It is an orthopedic tenet that a rigidly fixed implant is less likely to become infected. Thus, every effort is made to eliminate any relative motion between the mesh and the surrounding soft tissue.

With regard to hernia recurrence, our experience suggests that repair failure is more closely tied to inadequate distribution of forces than to the wound healing factors emphasized by the VHWG grading scale. Although wound infection is clearly associated with greater rates of recurrence, the role of infection is overly represented in the VHWG scale. Wound complications can be minimized through the modifications in technique previously discussed. However, there are a substantial number of repair failures that occur in the absence of a wound-related complication. These recurrences are best explained by inadequate distribution of forces across the repair.

We agree with the VHWG that centralization of the rectus complex, with components separation when needed, is critical for optimal distribution of tension across the repair. Release of the external oblique increases the intra-abdominal volume and improves the compliance of the lateral abdominal wall. A compliant lateral abdominal wall serves to absorb some of the force generated by abdominal wall contraction, rather than transmitting the entire force to the midline repair. The force that is transmitted to the midline is distributed across three parallel suture lines, with the mesh acting as pledge to prevent individual suture pull through. The combination of the narrow mesh underlay and the lateral release allows the midline repair to tolerate greater tension than was previously thought prudent based on the “tension-free” approach to hernia repair. Preclinical studies suggest that increasing abdominal wall compliance is a more effective way to reduce recurrence than minimizing tension or increasing the tensile strength of the repair construct. In addition, the soft-tissue coverage afforded by reapproximation of the rectus muscles minimizes the infection-related recurrences that plague large mesh patches and bridged repairs.

For these reasons, particular diligence should be paid to avoiding bridged repairs. Although they are designed to minimize tension, bridged repairs are particularly prone to failure because of compromised soft-tissue coverage, larger mesh requirements, decreased lateral abdominal wall compliance, and the unequal concentration of forces along the junction between the mesh and the abdominal wall. During the study time period, more than 230 hernia repairs were performed, with only 5 cases requiring bridged repairs due to an inability to sufficiently medialize the rectus complexes.

While emphasizing the importance of technique, the safe and reliable use of intraperitoneal synthetic mesh in this series not only challenges the VHWG recommendations but also the general consensus that polypropylene cannot be used safely in this position. In a thorough review of the literature regarding the use of intraperitoneal polypropylene, we found the data driving this consensus to be anecdotal, outdated, or inappropriately applied to the elective hernia setting. In fact, the reports that serve as the foundation for the operative dogma pertaining to intraperitoneal polypropylene represent results attained under the worst possible conditions—large sheets of heavy-weight mesh used in inflamed and contaminated fields, often with bowel injury and without adequate soft tissue coverage.

More recent studies in which investigators evaluate the use of polypropylene for elective hernia repair convey a more favorable complication profile. In 2 European studies, the authors specifically report the effective use of polypropylene mesh in clean-contaminated settings. Recognizing the limitations of this retrospective, single-surgeon series, this study does not provide enough evidence to advocate for the intentional placement of polypropylene mesh against the bowel. That said, these findings do suggest that polypropylene mesh can be used safely as an intraabdominal underlay, despite incidental or often-unavoidable bowel contact, when used in accordance with the principles previously outlined.

In conclusion, the effective use of synthetic mesh in this series questions the utility of the VHWG grading system as a guide for mesh material selection. These study findings reinforce the interdependence of mesh material and repair technique, and suggest that patient risk factors can be offset by a technical approach that distributes tension, optimizes compliance, and preserves robust wound perfusion.

REFERENCES


