Modified Mayo Technique for Ventral Hernia Repair: A Experimental Study

A. Toro¹, G. Stella¹, A. Gueli¹, M. Mannino¹, F. Palermo¹, G. Burrafato¹, and I. Di Carlo¹

¹Department of Surgical Sciences, Organ Transplantation and Advanced Technologies, University of Catania, Cannizzaro Hospital, Catania, Italy
²Department of Physics and Astronomy, University of Catania, Catania, Italy
³Department of Internal and Specialist Medicine, Section of Infectious Disease, University of Catania, Catania, Italy

Abstract

Background: To reduce the rate of recurrence of incisional hernia repair associated with open anatomic techniques, we present an experimental study, focusing on two different sutures, with the aim to apply clinically in a revised version of the Mayo technique.

Methods: Thirteen biological tissue samples from adult pig central brawn and upper and lower fasciae were measured using two techniques defined as “unbroken suture thread” and “separated suture stitches” to test the breaking resistance of the two types of suture.

Results: The t test results show that the two sets can be considered as different populations. The mean tensile stress $\sigma_{\text{max}}$ is greater (with reduced deviation) for the specimens of the set sutured with unbroken thread technique. Student’s t-test performed on values obtained for each set of samples indicated that the unbroken thread suture technique corresponds to higher ultimate failure strength.

Conclusion: Considering these results, a modified Mayo technique with continuous closure could be suggested. Of course a valid clinical study is required to better clarify this experimental hypothesis.

Key words: ventral hernia, open hernia repair, Mayo technique, open surgery
Background

Incisional hernia is one of the most frequent complications after abdominal surgical operations, with a reported incidence up to 20% (1). Among different techniques, the Mayo technique is one of the most common approaches to the repair of incisional, umbilical, and epigastric hernias (2). The rate of recurrence after primary hernia repair ranges from 24% to 54% (3). This high percentage of recurrences and the use of particular types of meshes are some of the most relevant reasons for high costs in this surgical field (3).

Open-mesh repair has a lower recurrence rate when compared with primary closure without mesh, but it is more expensive, it requires more time for execution, it is more frequently affected by infections and wound-related complications than is anatomic repair (4) and lastly not all the hospitals in the world can support the cost of the mesh.

To reduce the rate of recurrence of incisional hernia repair associated with open anatomic techniques, we present an experimental study, focusing on two different sutures, with the aim to apply clinically in a revised version of the Mayo technique.

Methods

This study has been approved by local ethics committee of Cannizzaro Hospital. To test the breaking resistance of 2 types of sutures, 13 biological tissue samples from adult pig central brawn and upper and lower fasciae were measured. The specimens were obtained in such a way so as to guarantee a similar morphology (Fig. 1A) and were subdivided in 2 groups named the A set and B set, consisting, respectively of 7 and 6 samples. For each one, an incision was made along the longitudinal axis (Fig. 1B) and was subsequently sewn using the 2 techniques. In samples from the A set, the cut was closed using a single thread (a technique denoted as “unbroken suture thread”), while the standard technique involving “separated suture stitches” was applied on specimens from the B set. Dimensions and laboratory codes of each sample are reported in Table 1.

The tissue specimens were spread on a plate and cut to the chosen α size of 100 mm with a scalpel. The thickness b and the initial length L0 were measured with a precision of ± 0.1 mm. Each piece of tissue was then stretched with the experimental setup shown in Fig. 2, expressly designed for the present study. The samples were clamped on both extreme sides parallel to the suture line and were subjected to tensile stress under varying rates of strain until the point of rupture. The suture line was transversally stretched by an increasing extension device, and the load F was measured using the high performance IMADA (Elis Electronic Instruments & Systems Srl, via Pietro Bembo 110, 00168 Roma, Italy) digital force gauge ZP–1000 N (Fig. 2) with a precision of ± 1 N. ZP-Recorder was the dedicated software used for managing and analyzing experimental data. A Mitutoyo (Mitutoyo Italiana, Corso Europa 7, 20020 Lainate (MI), Italy) digimatic scale unit (Model 572-21602) was used for measuring the displacement L (± 0.1 mm) of the side subjected to tensile load (Fig. 2). The load values at rupture, Fmax, were estimated for each sample.

Statistical analysis

The means and standard deviation values for the A set (mA and sA) and B set (mB and sB) were used for the t-test, which was applied to verify whether data belonged to different statistical populations.

The value of the t parameter was obtained as:

\[ t = \frac{m_A - m_B}{s} \sqrt{\frac{1}{n_A} + \frac{1}{n_B}} \]

where nA and nB are the numbers of observations for the 2 sets, and s is the mean standard deviation. (4)

Results

Experimental

Figure 3 shows the trend of tensile stress σ, Fmax/area ratio, reported in MPa, vs. the elongation ε (where ε = ΔL/L0), for
Table 1. Dimensions, laboratory code, load and tensile stress at rupture for the 2 series of samples

<table>
<thead>
<tr>
<th>Samples</th>
<th>Laboratory code</th>
<th>Dimensions</th>
<th>Load</th>
<th>Tensile stress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$L_0$</td>
<td>$a$</td>
<td>$b$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SET A</td>
<td></td>
<td>19.2</td>
<td>100</td>
<td>19.5</td>
</tr>
<tr>
<td>unbroken suture thread</td>
<td>A1</td>
<td>45.5</td>
<td>100</td>
<td>21.0</td>
</tr>
<tr>
<td></td>
<td>A2</td>
<td>24.0</td>
<td>100</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>A3</td>
<td>30.0</td>
<td>100</td>
<td>15.0</td>
</tr>
<tr>
<td></td>
<td>A4</td>
<td>22.0</td>
<td>100</td>
<td>16.0</td>
</tr>
<tr>
<td></td>
<td>A5</td>
<td>38.0</td>
<td>100</td>
<td>19.5</td>
</tr>
<tr>
<td></td>
<td>A6</td>
<td>26.0</td>
<td>100</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>A7</td>
<td>43.0</td>
<td>100</td>
<td>15.0</td>
</tr>
<tr>
<td>SET B</td>
<td></td>
<td>28.0</td>
<td>100</td>
<td>18.0</td>
</tr>
<tr>
<td>separated suture stitches</td>
<td>B1</td>
<td>22.0</td>
<td>100</td>
<td>10.0</td>
</tr>
<tr>
<td></td>
<td>B2</td>
<td>40.0</td>
<td>100</td>
<td>14.0</td>
</tr>
<tr>
<td></td>
<td>B3</td>
<td>30.0</td>
<td>100</td>
<td>13.5</td>
</tr>
<tr>
<td></td>
<td>B4</td>
<td>22.0</td>
<td>100</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Figure 2. Experimental setup for the tensile stress trials

Discussion

Ventral hernia is the protrusion of viscera through the anterior abdominal wall. The term includes umbilical, epigastric, incisional and, less commonly, Spigelian hernias.

Accepted risk factors for developing a primary incisional hernia are obesity, chronic cough, prostatism, constipation, diabetes mellitus, ascites and use of corticosteroids, even if the actual impact of this condition remains controversial (5).

The Mayo technique, originally performed by Mayo himself
in 1895, is still one of the techniques executed most commonly to repair umbilical, epigastric and incisional hernias (2,6) and has a recurrence rate ranging from 20 to 28% (7). The original technique is based on the Mattress sutures that are introduced 3 cm from the margin of the overlay fascia, and the overlaying margin that is linked to the edge of the underlying margin with a loop. Normally, the free margin of the overlaying fascia is sutured on the surface of the abdominal wall by a non-continuous suture (8). It is important to emphasize that the Mayo technique makes use of an interrupted suture to fix the free margin of the overlay fascia, while the possibility for using continuous suture was not considered by the author. Experimental set-up and measured quantities differ in biomechanical studies, depending on the application and objective. The primary stabilities of meniscal suturing techniques were measured by evaluating the ultimate failure strength (in N) with a tensometer; the results were assessed with the force elongation diagram (9,10). High precision in load-to failure tests is ensured by a digital record of displacement (mm); (11) this is necessary to consider stiffness (N/mm) in the case of evaluation of tensile forces applied to skin and tendon during suturing (12). Some experimental trials of the mechanical behavior of previously sutured biological tissues were performed with devices that are able to graphically and simultaneously record the load and the strain to which the sample is subjected. This information is used to calculate the stress/strain curves (13,14). According to previous tensile load tests on the ventral abdominal wall15, we measured the tension load/surface (N/mm) at the time of rupture at constant extension speed, and stress-strain diagrams were drawn (16). The set-up of the present interest for our application, through use of a clamping system that ensures uniform distribution of the tensile stress to the entire specimen. The appropriate software allows calculation of the cross-sectional area of each sample and of the tensile parameters stress $\sigma$ and strain $\varepsilon$, which yield the maximum tensile strength, $\sigma_{\text{max}}$.

### Table 2. Parameters and results of the $t$ test

<table>
<thead>
<tr>
<th>Set of samples</th>
<th>A set</th>
<th>B set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td>$n_A=7$</td>
<td>$n_B=6$</td>
</tr>
<tr>
<td>Mean $\sigma_{\text{max}}$</td>
<td>$m_A=0.334$</td>
<td>$m_B=0.207$</td>
</tr>
<tr>
<td>Mean standard deviation</td>
<td>$s_A=0.016$</td>
<td>$s_B=0.046$</td>
</tr>
<tr>
<td>Welch-corrected $t$ value</td>
<td>6.467</td>
<td></td>
</tr>
</tbody>
</table>

![Figure 3. Stress/strain curves for (A) unbroken suture thread technique (A6 specimen) and (B) separated suture stitches (B5 specimen)](image)

![Figure 4. Mean tensile stress for the 2 sets of specimens](image)
Student’s t-test performed on values obtained for each set of samples indicated that the unbroken thread suture technique corresponds to higher ultimate failure strength.

Many studies concerning fascia closure techniques (17-19) have evaluated the differences between continuous and interrupted sutures by comparing operating time, amount of thread used, post-operative infections and pain, fistula formation, tightness and recurrence. The continuous suture, compared with the interrupted one, is faster and stronger, reducing both the need for anesthesia and operating time. It also enables the physician to spare thread, reducing the amounts of knots used to suture, with fewer foreign bodies inside the incision.

For all these reasons, the present study suggests that a continuous suture can be used to fix the fascia to the surface of the abdominal wall instead of the original interrupted suture, resulting in an easy, economical, safe and improved modification. Based on the results of the present experimental study a proposal for current mayo modified surgical technique can be suggested. In this modified technique the margins of the free fascia are approximated to close the defect with a non-absorbable mattress suture 3 cm from the margin of the overlay fascia. In this way, the fascia is doubled with different sutures that represent a modification of the original technique: the free margin of the overlay fascia is fixed to the surface of the contralateral fascia with non-absorbable and running sutures.

Conclusions

Considering these results, a modified Mayo technique with continuous closure could be suggested. Of course a valid clinical study is required to better clarify this experimental hypothesis.

Competing interests

The author(s) declare that they have no competing interests.

Author’s contribution


All authors read and approved the final manuscript.

Acknowledgements

The authors thank Elia Pulvirenti, M.D. for his help in the initial work on the database.

The authors cordially acknowledge the technical assistance and useful suggestions of Mario Mazzeo, Antonio Rapicavoli and Vito Sparti, technicians at the Department of Physics and Astronomy, University of Catania.

References