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Modified Mayo Technique for Ventral Hernia Repair: A Experimental Study

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Rezumat

Tehnica Mayo pentru cura chirurgicală a herniei ventrale modificată: un studiu experimental

Introducere: Pentru a reduce rata recurențelor eventrațiilor secundare chirurgiei reparatorii a herniilor asociată cu tehnicile chirurgicale deschise vă prezentăm un studiu experimental axat pe două tipuri de suturi, cu scopul de a fi aplicate clinic într-o versiune revizuită a tehnicii Mayo.
Metode: Treisprezece probe de țesut biologic de porc adult, musculatura centrală și fascii superioară și inferioară, au fost evaluate utilizând 2 tehnici definite ca „sutură neîntreruptă" și „suturi separate", pentru a testa rezistența la rupere a celor două tipuri de suturi.
Rezultate: Rezultatele testului t arată că cele două tipuri de suturi pot fi considerate ca populații diferite. Stresul tensor mediu smax este mai mare (cu deviație standard redusă) pentru specimenele supuse tehnicii cu sutură neîntreruptă. Testul Student T aplicat valorilor obținute pentru fiecare set de probe a indicat că tehnica cu sutură neîntreruptă se asociază cu un grad final de rezistență la rupere mai crescut.
Concluzii: Luând în considerare aceste rezultate, o tehnică Mayo modificată cu sutură continuă ar fi recomandabilă. Desigur, este necesar un studiu clinic valid pentru a clarifica această ipoteză experimentală.

Cuvinte cheie: hernie ventrală, cura prin chirurgie deschisă a herniei, tehnică Mayo, chirurgie deschisă

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 σ_{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

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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 L_0 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, F_{max}, were estimated for each sample.

Statistical analysis

The means and standard deviation values for the A set (m_A and s_A) and B set (m_B and s_B) 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:

$$t = \frac{m_A - m_B}{s} \sqrt{\frac{n_A n_B}{n_A + n_B}}$$

where n_A and n_B 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, $F_{max}/area$ ratio, reported in MPa, vs. the elongation ε (where $\varepsilon = \Delta L/L_0$), for

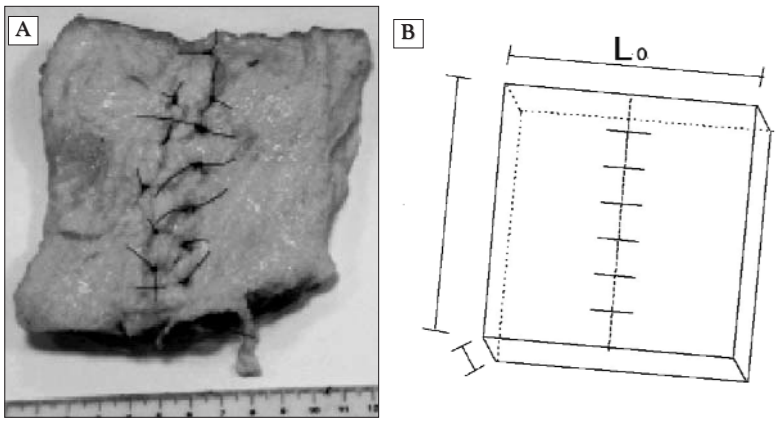

Figure 1. *(**A**) representative pattern with dimensions (**B**) for the specimens under study*

Table 1. *Dimensions, laboratory code, load and tensile stress at rupture for the 2 series of samples*

Samples	Laboratory code	Dimensions			Load	Tensile stress
		L_0	a	b	F_{max}	σ_{max}
		mm			N	MPa
SET A unbroken suture thread	A1	19.2	100	19.5	628	0.319
	A2	45.5	100	21.0	738	0.348
	A3	24.0	100	17.0	587	0.346
	A4	30.0	100	15.0	471	0.317
	A5	22.0	100	16.0	536	0.351
	A6	38.0	100	19.5	625	0.318
	A7	26.0	100	13.5	462	0.342
SET B separated suture stitches	B1	43.0	100	15.0	375	0.252
	B2	28.0	100	18.0	329	0.234
	B3	22.0	100	10.0	143	0.172
	B4	40.0	100	14.0	345	0.249
	B5	30.0	100	13.5	253	0.197
	B6	22.0	100	12.0	166	0.138

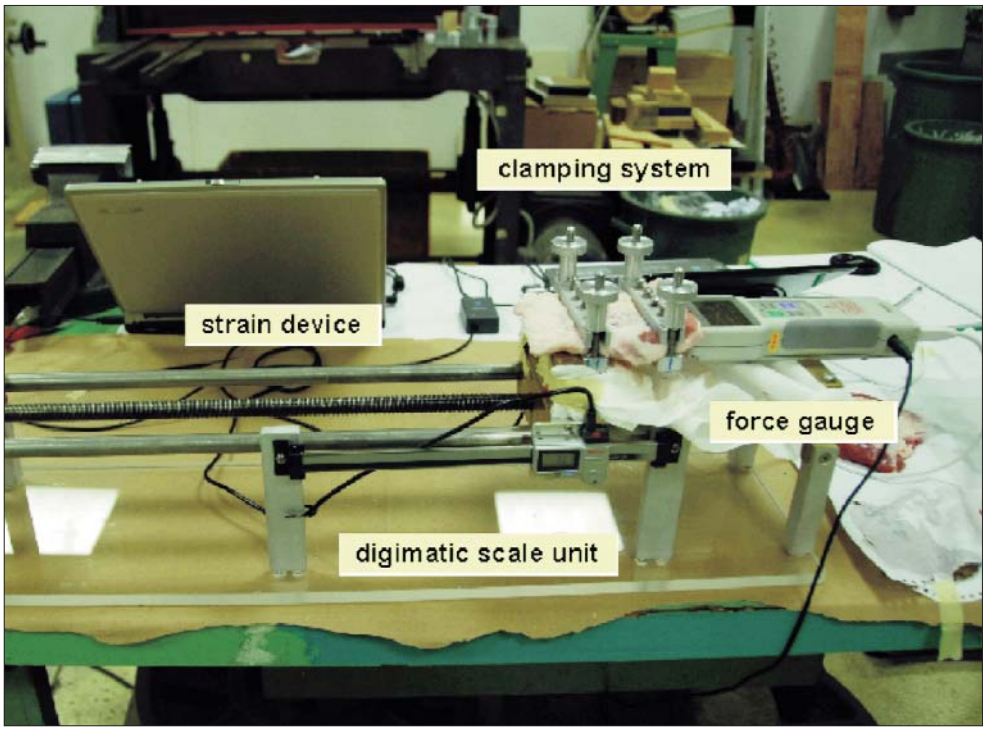

Figure 2. *Experimental setup for the tensile stress trials*

one sample specimen of each set, with unbroken suture thread (solid line) and separated suture stitches (dashed line), respectively. The data related to stress at rupture, σ_{max}, are shown in *Table 1* for each specimen.

Table 2 shows the parameters used for the *t* test and related results.

The *t* test results show ($P < 0.05$) that the 2 sets can be considered as different populations. *Figure 4* reports the mean values of the two data series with respective standard deviations. From the graphs, one can infer that the mean tensile stress σ_{max} is greater (with lower deviation) for the specimens of the A set sutured with unbroken thread technique. Using this last *modus operandi*, more regular suture lines with a greater resistance to rupture than those obtained by separated stitches are achieved.

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, prostat¬ism, 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

Table 2. *Parameters and results of the t test*

Set of samples	A set	B set
Number of observations	n_A=7	n_B=6
Mean σ_{max}	m_A=0.334	m_B=0.207
Mean standard deviation	s_A=0.016	s_B=0.046
Welch-corrected *t* value	6.467	

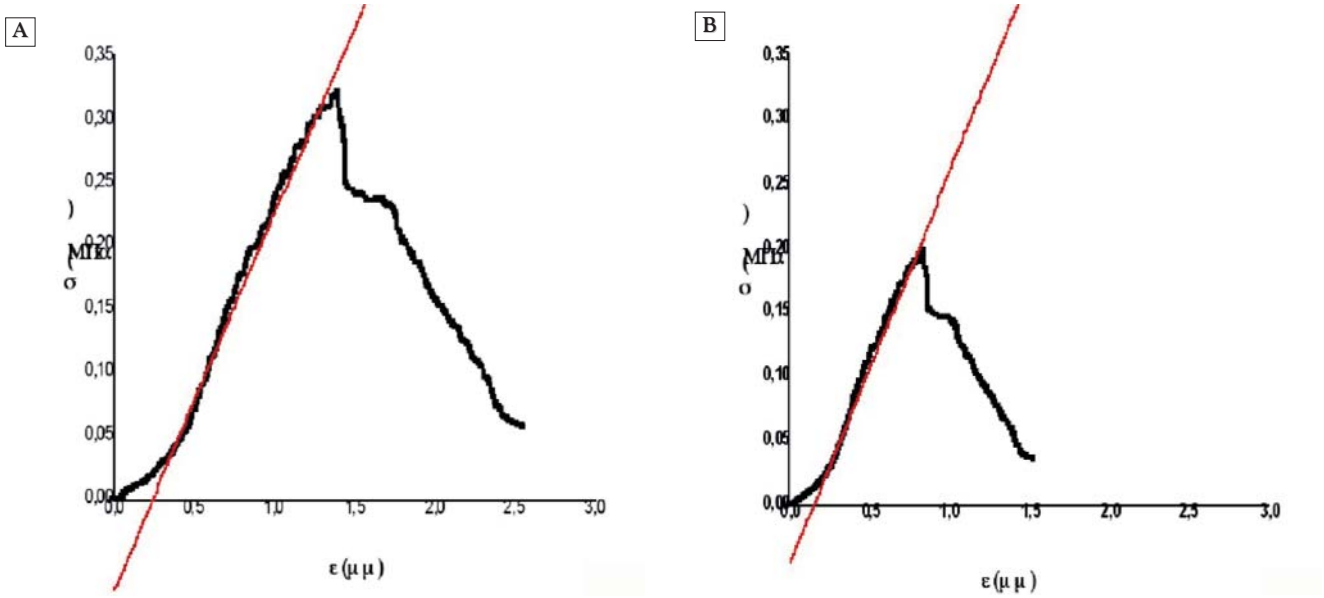

Figure 3. *Stress/strain curves for* ***(A)*** *unbroken suture thread technique (A6 specimen) and* ***(B)*** *separated suture stitches (B5 specimen)*

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^2) 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 σ and strain ε, which yield the maximum tensile strength, σ_{max}.

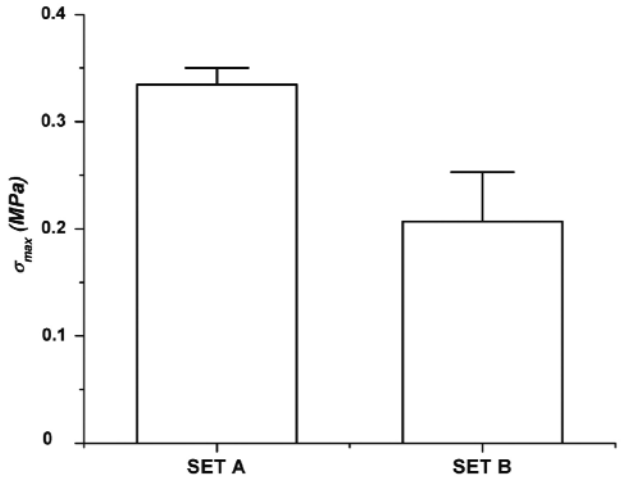

Figure 4. *Mean tensile stress for the 2 sets of specimens*

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

Study conception and design: Toro A, Di Carlo I. Acquisition of data: Stella G, Gueli A, Mannino M. Analysis and interpretation of data: Palermo F. Burrafato G, Di Carlo I. Drafting of manuscript: Toro A, Stella G. Critical revision of manuscript: Di Carlo I, Burrafato G, Palermo F, Toro A, Gueli A, Stella G.

All authors read and approved the final manuscript.

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References

1. Wassenaar E, Schoenmaekers E, Raymakers J, Van der Palen J, Rakic S. Mesh-fixation 3 method and pain and quality of life after laparoscopic ventral or incisional hernias repair: a 4 randomized trial of three fixation techniques. Surg Endosc 2010; 24: 1296-302.
2. Mittermair RP, Klingler A, Wykypiel H, Gadenstätter M. Vertical Mayo repair of midline incisional hernia: suggested guidelines for selection of patients. Eur J Surg 2002; 168:334-348.
3. Kraft RO, Harold KL. Laparoscopic repair of incisional and other complex abdominal wall 11 hernias. Perm J 2009; 13:38-42.
4. Misra MC, Bansal VK, Kulkarni MP, Pawar DK. Comparison of laparoscopic and open re¬14 pair of incisional and primary ventral hernia: results of a prospective randomized study. Surg Endosc 2006; 20:1839-1845.
5. Dietz UA, Hamelmann W, Winkler MS, Debus ES, Malafaia O, Czeczko NG, et al. An alternative classification of incisional hernias enlisting morphology, body type and risk factors in the assessment of prognosis and tailoring of surgical technique. J Plast Reconstr Aesthet Surg 2007; 60: 383-388.
6. Luijendijk RW, Lemmen MH, Hop WC, Wereldsma JC. Incisional hernia recurrence following "vest-over-pants" or vertical Mayo repair of primary hernias of the midline. World J Surg 1997; 21: 62-65.
7. Mayo WJ. An operation for the radical cure of umbilical hernia. Ann Surg 1901; 34: 276-280.
8. Trimbos JB, Smit IB, Holm JP, Hermans J. A randomized clinical trial comparing two methods of fascia closure following midline laparotomy. Arch Sur1992; 127: 1232-1234.
9. Rimmer MG, Nawana NS, Keene GC, Pearcy MJ. Failure strengths of different meniscal suturing techniques. Arthroscopy 1995; 11: 146-150.
10. Aşik M, Şener N, Akpinar S, Durmaz H, Göksan A. Strength of different meniscus suturing techniques. Knee Surg, Sports Traumatol Arthroscopy 1997; 5: 80-83.
11. Baums MH, Buchhorn GH, Spahn G, Poppendieck B, Schultz W, Klinger HM. Biomechanical characteristics of single-row repair in comparison to double-row repair with consideration of the suture configuration and suture material. Knee Surg Sports Traumatol Arthrosc 2008; 16: 1052-1060.
12. Frick TB, Marucci DD, Cartmill JA, Martin CJ, Walsh WR. Resistance forces acting on suture needles. J Biomech 2001; 34: 1335-1340.
13. García Páez JM, Jorge-Herrero E, Carrera A, Millán I, Rocha A, Calero P, et al. Ostrich pericardium, a biomaterial for the construction of valve leaflets for cardiac bioprostheses: mechanical behavior, selection and interaction with suture materials. Biomaterials 2001; 22: 49 2731–2740.
14. García Páez JM, Jorge Herrero E, Carrera Sanmartín A, Millán I, Cordon A, Martín Maestro M, et al. Comparison of the mechanical behaviors of biological tissues subjected to uniaxial tensile testing: pig, calf and ostrich pericardium sutured with Gore-Tex. Biomaterials 2003; 24: 1671-1679.
15. Hollinsky C, Sandberg S. Measurement of the tensile strength of the ventral abdominal wall in comparison with scar tissue. Clin Biomech 2007; 22: 88-92.
16. Sogol K, Ismaeil H. Mechanical influence of static versus dynamic loadings on parametrical analysis of plasticized ethyl cellulose films. Int J Pharm 2010; 408: 1-8.
17. Mushaweck U (2003) Umbilical and epigastric hernia repair. Surg Clin North Am 2003; 83: 1207-1221
18. Venclauskas L, Silanskalte J, Kludelis M. Umbilical hernia: factors indicative of recurrence. Medicina (Kaunas) 2008; 44: 855-859.
19. O'Dwyer PJ, Courtney C. Factors involved in abdominal wall closure and subsequent incisional hernia. Surgeon 2003; 1:17-22.