



Original article

Elective and Emergent Laparotomy Closure: The Importance of Protocolizing the Technique[☆]



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Background: Incisional hernias are a frequent complication, and their prevention includes proper closure of the abdominal wall.

Methods: A prospective study was conducted at a third-level hospital after the introduction of a midline laparotomy closure protocol. An objective measurement of the suture length to incision length ratio was made, and the postoperative results were analyzed.

Results: 127 patients were included and 34 of them (26.8%) had received a technically deficient closure. Incisional hernia was described in 20.5% of cases. An improvement in the quality of the abdominal wall closure was demonstrated over time.

Conclusion: The abdominal wall closure was deficient in nearly one-quarter of the laparotomies performed at a third-level medical center. A protocol improved the quality of the laparotomy closure.

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Cierre de la laparotomía electiva y urgente. Importancia de protocolizar la técnica

R E S U M E N

Introducción: La hernia incisional es una patología altamente prevalente cuya prevención incluye medidas como el correcto cierre de la pared abdominal.

Métodos: Se llevó a cabo un estudio prospectivo en un centro de tercer nivel que incluyó a pacientes intervenidos de modo electivo y de urgencias tras la implementación de un protocolo de cierre de la laparotomía media. Se realizó una medida objetiva de la relación

Palabras clave:

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entre la sutura usada y la longitud de la laparotomía y se analizaron los resultados postoperatorios.

Resultados: De los 127 pacientes incluidos, 34 (26,8%) recibieron un cierre técnicamente deficiente. La incidencia de hernia incisional fue del 20,5%. Se demostró una mejoría progresiva en la calidad del cierre.

Conclusiones: El cierre de la pared abdominal es deficiente en cerca de una cuarta parte de las laparotomías realizadas en un centro de tercer nivel. La implementación de un protocolo de cierre mejora la calidad del mismo.

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Introduction

The prevalence of incisional hernias (IH) after midline laparotomy can reach 35%.¹ In 1976, Jenkins established the basis for the closure of abdominal incisions, defining the minimum ratio of 4:1 between the length of the suture used and the length of the wound (SL:WL) as a basic parameter for quality.² The data from the most current literature seem to indicate that an SL:WL > 4:1 with continuous suture of slow-absorbing material reduces the IH rate.³ However, laparotomy closure remains controversial. A recent Cochrane review presents moderate-quality evidence showing the superiority of using absorbable and monofilament material, as well as very low evidence regarding other aspects, such as mass closure or the use of continuous suture.⁴ The “small bite” technique, with sutures that are close together and close to the midline (3–6 mm), seems to increase the resistance of the tissues.⁵ Another recent systematic review in the context of elective surgery concludes that the small bite technique, which leads to an increase in SL:WL, is the technique of choice for laparotomy closure.⁶ The follow-up and implementation of specific clinical guidelines, particularly the recommendations of the European Hernia Society published after the start of this study, should potentially improve IH incidence results.⁷ In the context of emergencies, a prospective study after the implementation of a closure protocol demonstrated a reduction in IH compared to a historical cohort.⁸

Considering this context, there seems to be room for improvement in the midline laparotomy closure technique. According to an abdominal wall closure survey conducted in 2013 with 131 surgeons and residents, close to half of the respondents were unaware of or did not know how to apply the 4:1 technique.⁹ The objective measurement of the SL:WL ratio may be absent in standard daily practice. This would be the first step to detect factors that may be improved based on current knowledge. Developing a protocol for the basic surgical technique of laparotomy closure may be beneficial in reducing IH rates.

The main objective of this study was to prospectively and systematically analyze the midline laparotomy closure technique after the implementation of a closure protocol at a tertiary hospital, in the context of both urgent and elective surgery.

Methods

A prospective study was conducted over a period of 3 years, from October 2014 to October 2017, after the implementation of an abdominal wall closure protocol. The project and patient follow-up were approved by the Ethics Committee. The study included patients undergoing midline laparotomy, as well as assistance laparotomies in laparoscopic procedures, in the context of both emergency and elective surgeries. We excluded patients who had undergone other types of laparotomy, those who had a history of IH or who had midline IH at the time of surgery, and patients included in other abdominal wall studies. All patients gave their signed informed consent.

The closure technique was done in both groups under the same guidelines, in accordance with the conclusions of the INLINE¹⁰ systematic review and meta-analysis. These included single-layer closure with continuous slow-absorption polydioxanone sutures (2/0 PDS, Ethicon®). In addition, an SL:WL of at least 4:1 was established with the small bite technique. The technique had been recorded on video and shown to all participating surgeons, meaning the entire General Surgery department, including residents and assistant surgeons. No previous experimental training was conducted. The SL:WL ratio was systematically recorded after intraoperative measurement of both lengths in centimeters with a sterile malleable ruler, using the formula described by Israelsson.¹¹

The anesthetic risk was recorded according to the scale of the American Society of Anesthesiologists.¹² Factors related to the appearance of hernias were registered, such as diabetes, tobacco habit, constipation, chronic obstructive pulmonary disease, use of corticosteroids and immunosuppressants, aortic aneurysm pathology or previous history of midline laparotomies.^{13,14} The characteristics of the surgical procedure were also recorded according to whether they were urgent or elective and the reason for the intervention (colon, small intestine, gastric or other pathology). The degree of contamination was described according to the description of the Centers for Disease Control and Prevention, defining the surgery as clean, clean-contaminated, contaminated or dirty.¹⁵ Other recorded data included the use of prophylactic antibiotic therapy, wall retention measures (total points) and closure by the attending surgeon or resident, without specifying the year of residence.

Immediate postoperative complications were recorded, including wound infection according to the criteria of the Centers for Disease Control and Prevention, evisceration, hematoma and reoperation during the first 30 days after surgery.¹⁶ Perioperative pain was also recorded, as defined by the visual analogue scale.¹⁷

The appearance of IH was assessed by physical examination 3 and 6 months after surgery, as well as a radiological evaluation by computed tomography (CT) at the 6-month follow-up visit; IH was considered an early complication of surgery.¹⁸ The presence of neoplastic pathology made it possible to adapt this control to the scheduled follow-up of the baseline pathology in the majority of patients. The diagnosis of IH was defined as the presence of a palpable mass under the surgical scar after Valsalva maneuvers on physical examination and an interruption between the abdominal rectus muscles on CT.

We analyzed the results from the total patient sample as well as the results from the following subgroups: patients operated on in the emergency department, patients who underwent elective surgery, patients with an SL:WL<4:1 (considered technically deficient) and patients with an SL:WL≥4:1. We also calculated the number of patients who did not comply with the SL:WL associated with the short bite technique (SL:WL 5:1).

Statistical Analysis

In the statistical analysis and the bivariate and multiple comparisons, the Chi-squared, ANOVA and Scheffé tests were used, establishing statistical significance as a P value <.05 value. IBM SPSS statistics version 2.0 software for Mac was used.

Results

A total of 127 patients who underwent midline laparotomy in the study period met the inclusion criteria.

In the analysis of the total sample, 17 patients (13.4%) had a history of hernia pathology outside the midline and 36 (28.3%) had previously undergone midline laparotomy. Laparotomy was performed in an emergency context in 50 patients (39.4%), and in 89 cases the reason was colon pathology (70.1%). Thirty-eight patients (29.9%) were treated in a situation of dirty or contaminated surgery. The demographic and surgical characteristics of the sample are shown in [Table 1](#).

In 85 cases (66.9%), the laparotomy was closed by the resident surgeon. The mean SL:WL ratio was 4.7:1. Both attending surgeons and residents closed with an average SL:WL ratio>4:1. The average size of the incision was 18.1 cm, with a minimum of 5 cm and a maximum of 32 cm.

[Table 2](#) shows the context in which the abdominal wall was closed and its characteristics.

The 6-month IH rate diagnosed by CT was 20.5%, while only 3 patients (2.4%) had a clinically detectable IH. An intention-to-treat analysis was completed. There were 8 patients who died during the first 6 postoperative months (6.3%) and 4 patients who were lost to follow-up (3.2%). Postoperative morbidity is shown in [Table 3](#).

Table 1 – Demographic and Surgical Characteristics of the Patients With Midline Laparotomy.

Midline laparotomy n=127	Frequency	Percentage
Females/Males	53/74	41.7/58.3%
Mean age	65.5 (DE: 17.5)	–
BMI	26.7 (DE: 5.2)	–
Smoker	21	16.5%
Diabetes mellitus	23	18.1%
Other hernias	17	13.4%
COPD	19	15%
Chronic constipation	1	0.8%
AAA	0	0%
Corticosteroids	13	10.2%
Immunosuppressants	6	4.7%
Previous laparotomy	36	28.3%
ASA III-IV	36	28.3%
Urgent surgery	50	39.4%
Colon surgery	89	70.1%
Gastric surgery	7	5.5%
Small intestine surgery	19	15%
Other surgery	12	9.4%
Closure by resident	85	66.9%
Retention measures	0	0%
Prophylactic antibiotic therapy	127	100%
Dirty and contaminated	38	29.9%
Clean-contaminated	77	60.6%
Clean	12	9.4%

ASA: American Society of Anesthesiologists; SD: standard deviation; COPD: chronic obstructive pulmonary disease; BMI: body mass index.

Closure was done in 34 patients (26.8% of the sample) with an SL:WL<4:1. The IH rate diagnosed by CT 6 months later was 23.5% in this group, compared to 19.4% in the group of patients with a ratio equal to or greater than 4:1, which was not statistically significant (P=.3). Two of the 5 eviscerations of the total sample occurred in the group with a technically deficient closure, representing 5.9% of the cases, with no observed statistically significant difference (P=.4). The comparison according to the technical quality of the closure is shown in [Table 4](#).

The small bite closure technique with an associated SL:WL rate ≥5:1 was only fulfilled in 41 of the cases reviewed (32.3%).

Table 2 – Laparotomy Closure Technique.

	Value/Frequency	Percentage
Ratio SL:WL (mean)	4.72 (SD: 1.3)	
Resident surgeons	4.79	
Attending surgeons	4.39	
Minimum	2.33	
Maximum	9.05	
Length of midline laparotomy	18 cm	
Minimum length	5 cm	
Maximum length	32 cm	
Small bites and SL:WL>5:1	41	32.3%
Closure technique		
Continuous suture	127	100%
PDS 2/0	127	100%

SD: standard deviation; SL:WL ratio: ratio between suture length and incision length.

Table 3 – Postoperative Results.

Midline laparotomy n=127	Frequency/Mean	Percentage
Wound infection	11	8.7%
Wound hematoma	6	4.7%
Evisceration	5	3.9%
Scar problems	8	6.3%
VAS 1st day PO	3.69	–
VAS discharge	1.33 (SD: 0.9)	–
Mortality (<6m)	8	6.3%
Lost to follow-up	4	3.2%
IH symptoms (6m)	3	2.4%
Eventration CT (6m)	26	20.5%

SD: standard deviation; VAS: visual analogue scale; IH: incisional hernia; PO: postoperative; CT: computed tomography.

Table 4 – Comparison According to Quality of Laparotomy Closure.

	SL:WL<4 n=34	SL:WL≥4 n=93	P
Mean age	67.9 (DE: 12.5)	64.9 (DE: 13.2)	.7
BMI	28.3 (DE: 5.7)	26.1 (DE: 5.1)	.1
Colon surgery	30 (88.2%)	59 (63.4%)	.008
Dirty/contaminated	10 (29.4%)	28 (30.1%)	1
Wound infection	2 (5.9%)	9 (9.7%)	.7
Wound hematoma	1 (2.9%)	5 (5.4%)	1
Scar problems	2 (5.9%)	6 (6.5%)	1
IH symptoms 6m	2 (5.9%)	1 (1.1%)	.1
Emergency	11 (32.3%)	37 (39.8%)	.5
Resident	24 (70.6%)	61 (65.6%)	.4
Evisceration	3 (8.8%)	2 (2.2%)	.1
IH 6m	8 (23.5%)	18 (19.4%)	.6

SD: standard deviation; IH: incisional hernia; BMI: body mass index; SL:WL: ratio between length of suture used and length of the incision.

Results were compared between patients who were operated on in an emergency situation and those who underwent elective surgery. In the emergency context, a lower percentage of laparotomies were closed by residents (57.1%) compared to the proportion found in elective surgeries, which was statistically significant ($P=.04$). In both groups, the mean value and the median SL:WL was higher than 4:1. The incisional hernia rate diagnosed radiologically at the 6-month follow-up was higher in the emergency group (22.5%), as was the rate of evisceration (6.1%), although no statistically significant differences were found (Table 5).

The mean SL:WL increased over the course of the study period. The chronological division into 3 time periods within the study provided SL:WL ratios of 4.28, 4.86 and 5.21, respectively. The last period studied had a significantly higher average ratio ($P=.027$) compared to the first. In this period, a lower IH rate was observed (11.6%), which was below the observed global rate, with no statistical significance ($P=.07$). The results over time in the study period are shown in Fig. 1.

Discussion

In the literature, an SL:WL ratio $\geq 4:1$ has been reported to be advantageous for the closure of midline laparotomies.¹⁹ The

Table 5 – Comparison of Laparotomy Closure According to Urgent or Elective Surgery.

	Urgent (n=49)	Elective (n=78)	P
Resident	28 (57.1%)	58 (74.4%)	.04
Mean SL:WL	4.3	4.6	
Median SL:WL	4.5	4.3	
Evisceration	3 (6.1%)	2 (2.5%)	.25
IH (CT 6m)	11 (22.5%)	15 (19.2%)	.65

IH: incisional hernia; SL:WL: ratio between length of suture used and incision length.

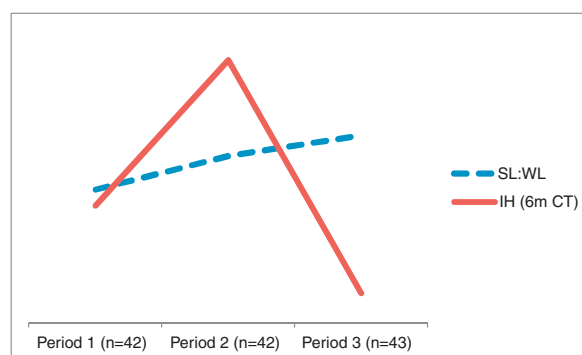


Fig. 1 – Evolution over time of the suture length/wound length ratio of the laparotomy (SL:WL) and incisional hernia (IH) diagnosed by computed tomography 6 months later (6m CT).

technical variability in the closure method, lack of knowledge about the 4:1 technique, clinical difficulties in emergency situations and little importance given mainly to the closure of laparotomies may all alter the closure technique.²⁰

Although IH are a consequence of several factors, technique is the only factor that depends exclusively on the surgeon.²¹ In a resident training program on abdominal wall closure techniques, a progressive improvement in technical skills was observed, as well as an initial lack of knowledge of the optimal relationship between suture length and incision length.²² It is necessary to homogenize the closure technique and systematically calculate the SL:WL ratio to assess the quality of the closure.²³ Our results show a progressive technical improvement in the closure of the abdominal wall throughout the study, with a lower IH rate in the last period of the study.

According to our study, the closure of laparotomies falls to a large extent on residents, especially in the context of elective surgery. In a review of 100 consecutive patients, the SL:WL ratio was calculated, which was equal to or greater than 4:1 in 76% of cases. The ratio below 4:1 was more frequent in closures performed by residents and was associated with a higher rate of wound infection.²⁴ In our sample, the average SL:WL ratio for both adjunct surgeons and residents is slightly higher than 4:1 and lower than 5:1. Only systematic measurement and calculation of this ratio can guarantee a technically correct closure.

A technically deficient closure (SL:WL<4:1) could be the cause of a higher IH rate. In this review, the results show 26.8% of patients with closures that could be considered incorrect due to not meeting the technical requirements. Although a higher IH rate was observed in this group of patients and in the patients with emergency procedures, these differences were not statistically significant. A greater participation of residents was observed in this subgroup, although this was not a statistically significant difference.

A greater proportion of patients treated for colon pathologies was found among the technically deficient closures (88.2 versus 63.4%), although the proportion of contaminated and dirty surgery in both groups was homogeneous. Colon surgery, due to its higher rate of surgical site infection compared to clean surgeries, presents a greater risk for IH.²⁵ For this reason, closure in these patients should be especially meticulous.

A prospective study that included 560 randomized patients demonstrated a lower rate of IH in elective midline laparotomies after closure with the small bite technique associated with a mean SL:WL ratio of 5:1.²⁶ Of the total number of patients studied in our sample, 86 did not receive a closure that met these requirements.

The present study shows 2 fundamental limitations: a limited sample size and a short follow-up. The limited sample was due to the exclusion of patients participating in other studies. However, it is an easily reproducible study that provides essential information about the technical quality of routine abdominal wall closure, both in an urgent and elective context.

Although the present study has a limited number of patients, it demonstrates a technical improvement in the closure of laparotomies after the establishment of a closure protocol and systematic collection of SL:WL data. However, no statistically significant differences were found in the presence of eviscerations, wound infections or in the appearance of IH based on this factor.

Although detection of IH can be done early on with CT, a higher rate of symptomatic and detectable IH can be expected on physical examination with follow-ups longer than 6 months.

The closure technique was deficient in one-quarter of midline laparotomies performed at a tertiary medical center as emergency or elective surgery. This proportion reached 70% when the small bite technique with an SL:WL ratio>5:1 was used as a reference, which is supported by current evidence in elective surgery.

The implementation of a closure protocol significantly improves technical results.

Both resident surgeons and adjunct surgeons are able to perform technically correct closures after proper training.

Resident surgeons are most involved in the closure of laparotomies, both in the context of emergency and elective surgeries.

Among the technically deficient closures, a higher rate of colon surgery is observed, with special attention being paid to this patient subgroup.

A greater number of patients is required to evaluate the impact of this technical improvement on the appearance of IH, as well as a longer-term follow-up.

The preventive effect of prophylactic mesh for the reduction of IH should be assessed, which was not done in this study as it was not among the objectives.

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Conflict of Interests

The authors have no conflict of interests to declare.

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REFERENCES

1. Bosanquet DC, Ansell J, Abdelrahman T, Cornish J, Harries R, Stimpson A, et al. Systematic review and meta-regression of factors affecting midline incisional hernia rates: analysis of 14,618 patients. *PLOS ONE*. 2015;10:e0138745.
2. Jenkins TP. The burst abdominal wound: a mechanical approach. *Br J Surg*. 1976;63:873-6.
3. Henriksen NA, Deerenberg EB, Venclauskas L, Fortelny RH, Miserez M, et al. Meta-analysis on materials and techniques for laparotomy closure: the MATCH review. *World J Surg*. 2018;42:1666-78.
4. Patel SV, Paskar DD, Nelson RL, Vedula SS, Steele SR. Closure methods for laparotomy incisions for preventing incisional hernias and other wound complications. *Cochrane Database Syst Rev*. 2017;11:CD005661.
5. Cengiz Y, Blomquist P, Israelsson LA. Small tissue bites and wound strength: an experimental study. *Arch Surg*. 2001;136:272-5.
6. Fortelny RH. Abdominal wall closure in elective midline laparotomy: the current recommendations. *Front Surg*. 2018;5:34.
7. Muysoms FE. European Hernia Society guidelines on the closure of abdominal wall incisions. *Hernia*. 2015;19:1-24.
8. Tolstrup MB, Watt SK, Gögenur I. Reduced rate of dehiscence after implementation of a standardized fascial closure technique in patients undergoing emergency laparotomy. *Ann Surg*. 2017;265:821-6.
9. Pereira JA, López-Cano M, Marsal F, Feliu X. Resultados de una encuesta nacional sobre el cierre de la pared abdominal. *Cir Esp*. 2013;91:645-50.
10. Diener MK, Voss S, Jensen K, Büchler MW, Seiler CM. Elective midline laparotomy closure: the INLINE systematic review and meta-analysis. *Ann Surg*. 2010;251:843-56.
11. Israelsson LA, Millbourn D. Prevention of incisional hernias. How to close a midline incision. *Surg Clin N Am*. 2013;93:1027-40.
12. Cullen DJ, Apolone G, Greenfield S, Guadagnoli E, Cleary P. ASA physical status and age predict morbidity after three surgical procedures. *Ann Surg*. 1994;220:3-9.
13. Hoer J, Lawong G, Klinge U, Schumpelick V. Factors influencing the development of incisional hernia. A retrospective study of 2,983 laparotomy patients over a period of 10 years. *Chirurg*. 2002;73:474-80.

14. Adell-Carceller R, Segarra-Soria MA, Pellicer-Castell V, Marcote-Valdivieso E, Gamon-Giner R, Martin-Franco MA, et al. Incisional hernia in colorectal cancer surgery. Associated risk factors. *Cir Esp.* 2006;79:42-5.
15. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, 1999. Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. *Am J Infect Control.* 1999;27:97-132 (quiz 133-134; discussion 196).
16. Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for prevention of surgical site infection, Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. *Am J Infect Control.* 1999;1999:100-1 (tabla 1).
17. Price DD, Bush FM, Long S, Harkins SW. A comparison of pain measurement characteristics of mechanical visual analogue and simple numerical rating scales. *Pain.* 1994;56:217-26.
18. Burger JW, Lange JF, Halm JA, Kleinrensink GJ, Jeekel H. Incisional hernia: early complication of abdominal surgery. *World J Surg.* 2005;29:1608-13.
19. Van Ramshorst GH, Klop B, Hop WC, Israelsson LA, Lange JF. Closure of midline laparotomies by means of small stitches: practical aspects of a new technique. *Surg Technol Int.* 2013;23:34-8.
20. Mingoli A, Puggioni A, Sgarzini G, Luciani G, Corzani F, Ciccarone F, et al. Incidence of incisional hernia following emergency abdominal surgery. *Ital J Gastroenterol Hepatol.* 1999;31:449-53.
21. van 't Riet M, Steyerberg EW, Nellensteyn J, Bonjer HJ, Jeekel J. Meta-analysis of techniques for closure of midline abdominal incisions. *Br J Surg.* 2002;89:1350-6.
22. Hope WW, Watson LI, Menon R, Kotwall CA, Clancy TV. Abdominal wall closure: resident education and human error. *Hernia.* 2010;14:463-6.
23. Williams Z, Williams S, Easley HA, Seita HM, Hope WW. An evaluation of abdominal wall closure in general surgical and gynecological residents. *Hernia.* 2017;21:873-7.
24. Williams ZF, Tenzel P, Hooks WB 3rd, Hope WW. Suture to wound length ratio in abdominal wall closure: how well are we doing? *Hernia.* 2017;21:869-72.
25. Murray BW, Cipher DJ, Pham T, Anthony T. The impact of surgical site infection on the development of incisional hernia and small bowel obstruction in colorectal surgery. *Am J Surg.* 2011;202:558-60.
26. Deerenberg EB, Harlaar JJ, Steyerberg EW, Lont HE, van Doorn HC, Heisterkamp J, et al. Small bites versus large bites for closure of abdominal midline incisions (STITCH): a double-blind, multicentre, randomised controlled trial. *Lancet.* 2015;386:1254-60.