Chapter 2

Small bites with small suture distances increase laparotomy closure strength

J. J. Harlaar
G. H. van Ramshorst
J. Nieuwenhuizen
J. G. ten Brinke
W. C. J. Hop
G. J. Kleinrensink
J. Jeekel
J. F. Lange

American Journal of Surgery (2009) 198, 392–395

Abstract

Background

There is no conclusive evidence which size of suture stitches and suture distance should be used to prevent burst abdomen and incisional hernia.

Methods

Thirty-eight porcine abdominal walls were removed immediately after death and divided into 2 groups: A and B (N=19 each). Two suturing methods using double-loop polydioxanone were tested in 14-cm midline incisions: group A consisted of large stitches (1 cm) with a large suture distance (1 cm), and group B consisted of small stitches (0.5 cm) with a small suture distance (0.5 cm).

Results

The geometric mean tensile force in group B was significantly higher than in group A (N=787 vs N=534; P=0.006).

Conclusions

Small stitches with small suture distances achieve higher tensile forces than large stitches with large suture distances. Therefore, small stitches may be useful to prevent the development of a burst abdomen or an incisional hernia after midline incisions.

Introduction

Suture techniques for midline incisions have been subject of investigation for a long period of time. Incidences of incisional hernia and burst abdomen after laparotomy are 2-20% and 1-3%, respectively. Although much is known about patient related risk factors, technical risk factors such as suture techniques have not been investigated thoroughly.[1-4] Especially in high-risk patients in whom incidences of incisional hernia are reported up to 35%, surgeons should take care to use optimal suture technique to avoid short and long-term complications.[5] The optimal suture technique should be easy to perform, quick, reliable and give high long-lasting breaking strengths to improve wound healing.

For prevention of incisional hernia, many clinical trials and meta-analyses have shown that a mass closure technique with simple running sutures is the best option to close a midline incision.[6-11] Such a technique is also more easily to perform and quicker than layered techniques with interrupted sutures.
Furthermore, the use of long lasting absorbable suture material compared with non-absorbable suture material decreases postoperative pain and wound infection.[9-12]

Israelsson has argued that a suture length to wound length ratio (SL:WL) of four or more must be achieved, since a lower ratio is associated with a threefold increase in the rate of incisional hernia.[13-15] It is often recommended to place continuous stitches more than 10 mm from the wound edge in combination with a long stitch length.[16-22] A long stitch is the result of a large bite with the largest portion of fascia possible, aiming to increase tensile strength and decreasing the risk of facial dehiscence. However, long stitches have been associated with high rates of both wound infection and incisional hernia.[13, 23, 24]

Israelsson and his group preformed experimental and clinical studies on suture technique in benefit of the small bites.[13-15, 25-28] Small stitches are placed 4–6 mm from the wound edge and cut only through the aponeurosis and not through the rectus abdominis muscle. Because the small stitch is placed in the aponeurosis only, it is also possible to place more stitches in one incision.

In daily practice, most surgeons use the large bite technique with large suture distances. With large bites, SL:WL ratio depends on the thickness of the abdominal wall including the muscles and the number of stitches. With small stitches, SL:WL ratio is mostly dependent on the number of stitches. There is no proof of principle which technique is the best option to close the abdominal wall to prevent incisional hernia and fascial dehiscence.

The aim of this study was to compare the large and small bites techniques on tensile strength and type of dehiscence in a controlled lab setting with use of porcine abdominal walls.

Materials and methods

Thirty-eight porcine abdominal walls (Yorkshire pigs, 40-60 kg) were removed immediately after sacrifice and were freezed at -20°C for at least 4 days (mean time 7 days).[29] After a defrosting period of 16 hours, fat and skin were removed, and a midline incision was made through the aponeurosis.

Two suturing methods using double loop polydioxanone (PDS II 1.0 Ethicon 240 cm) were tested in 14-cm-midline incisions: A) large bites (1 cm) with large suture distance (1 cm) with a total of 14 continuous stitches and B) small bites (0.5 cm) with small suture distance (0.5 cm) with a total of 28 continuous stitches. The techniques were used in alternate order and by two circulating investigators to avoid selection bias. To standardise the suture technique, the place of the stitch was measured with a ruler and marked with a needle (Braun sterican 0,5x16 mm), consequently the stitch were made. SL:WL ratios were calculated for all specimens.

Subsequently, abdominal walls were fixed on a tensile testing machine (Testometric® , Rochdale, England) (figure 1).[30] Tensile force was increased at a constant rate of 10 mm/min. Each test was filmed (Sony Cybershot DSC-S700, Japan) and type of dehiscence (e.g. aponeurosis, lateral of sutures, site of fixation or no dehiscence at maximum force) was recorded.

The test setting is shown in Figure 1.

Figure 1 Photograph of the test setting used. The sutured abdominal wall is fixed in the tensile testing machine and is pulled apart at a constant rate of 10 mm/min.

The force at the moment of the first drop resulting into dehiscence through the aponeurosis was considered the primary outcome. For experiments in which other types of dehiscence occurred it can be concluded that the true force to result in dehiscence through the aponeurosis will be greater than the recorded force (right-censored observation). To take account of such censored observations, STATA software was used (procedure CNREG). Forces were logarithmically transformed in this analysis to get approximate normal distributions. The same method was used to evaluate the relation between the SL:WL ratio and the primary outcome. P-values **<** 0.05 were considered significant. Power calculations based on pilot data had led to two groups of 19 abdominal walls each.

Results

In group A (large bites; n=19) and group B (small bites, n=19) there were respectively 14 and 7 experiments which resulted in dehiscence through the aponeurosis (P=0.049; Fisher's exact test). In group A there were 5 experiments not resulting in dehiscence through the aponeurosis (3 on the fixation device, 2 lateral to the incision). In group B there were 12 experiments not resulting in dehiscence through the aponeurosis (8 on the fixation device, 3 lateral to the incision).

Analyzing the resulting forces of all 38 experiments, the tensile forces in group B were significantly higher than in group A with geometric mean tensile force able to create dehiscence through the aponeurosis of 534 N in group A and 787 N in group B (P=0.006). This corresponds to a 47% increase. Following the law of Laplace and assuming a mean abdominal diameter of 30 cm, a tensile force of 360 N represents the force created by Valsalva's maneuver.

Mean SL:WL ratios were 4.1 (range 2.8 - 5.1) in group A and 6.9 (5.0 - 8.6) in group B. In group A, an increase in SL:WL ratio was significantly associated with an increase in tensile strength (P<0.001), with each 1 point higher SL:WL ratio resulting in a 61% increase in tensile strength (Figure 2). No significant relation was found in group B (P=0.102). In none of the tests knots had slipped or sutures had broken.

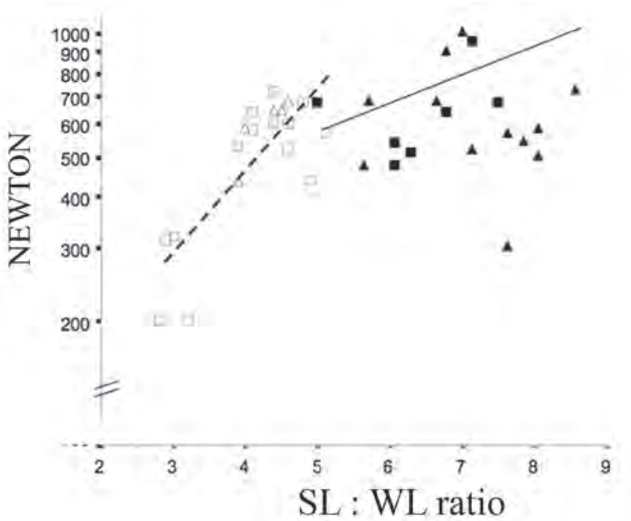
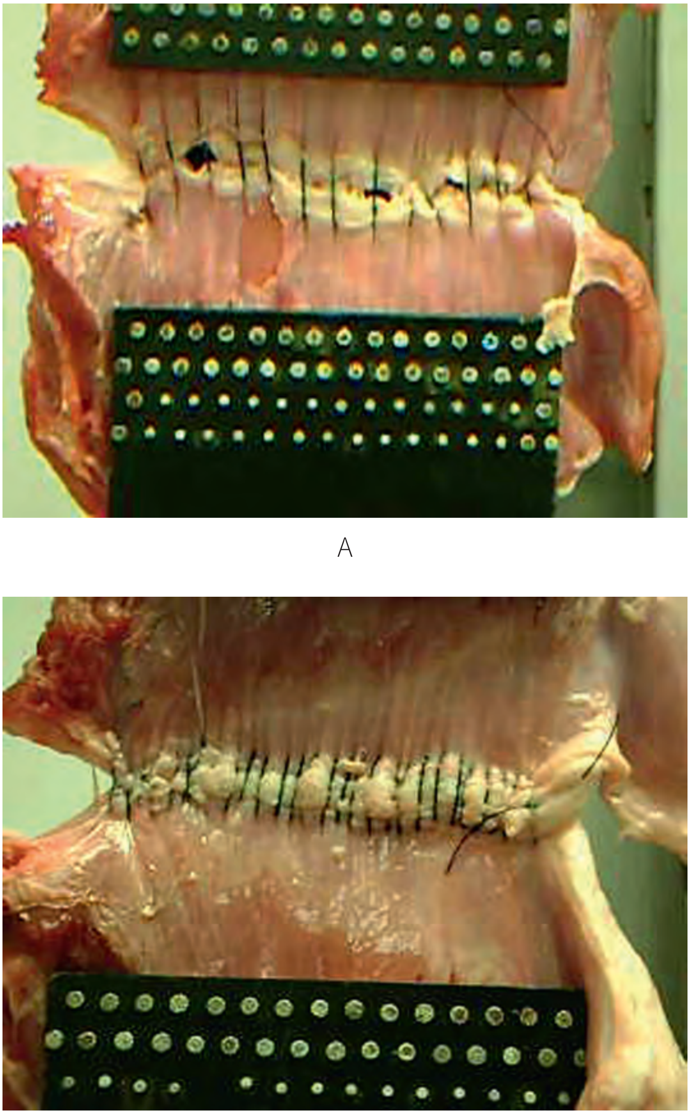


Figure 2 Scatter plot of tensile force versus the SL:WL ratio, with regression lines. Open and closed symbols represent tensile forces for group A (large stitches) and group B (small stitches), respectively. Triangles within each group represent forces that did not result in dehiscence through the aponeurosis (censored observations



A

B

Figure 3 (A) Large-stitch group: slacking effect. Example of the slacking effect in the large-stitch group. Sutures first cut through the relatively weak tissue lateral to the aponeurosis, causing wound edges to separate. (B) Small-stitch group. In the small-stitch group, separation of wound edges was not observed. This possibly is owing to a better distribution of tensile forces, resulting in dehiscence far lateral from the aponeurosis.

2

Type of dehiscence was very characteristic for group A compared with group B. During the experiments, large bites were slacking through the muscle and the most tensile force was generated when the sutures were hanging on the aponeurosis whilst the wound edges were separated. This effect has been described before.[27] When bites were placed in the aponeurosis and the slacking effect was not observed.

Discussion

This is the first experimental study comparing large versus small tissue bites with documented SL:WL ratios on breaking strength in a model anatomically comparable to humans. A number of rat studies has been performed on wound healing and bursting pressure in the past, but forces in small animals are hardly comparable to human physiology.

In the small bites group, more stitches resulted into a better division of tension over the abdominal wall. Furthermore, due to the achievement of high SL:WL ratios, tension was divided over a longer suture thread. In the large bites group, high SL:WL ratios were needed to create acceptable tensile strength and although standardized bites of one cm were used, half of all SL:WL ratios were below four. In the large bites group, the ratio is dependent on bite size, the thickness of the abdominal wall and the extent of force used to haul the suture.

This suture length wound length ratio of four, as described by Jenkins, was based on a mathematical approach.[31] No specifications concerning the desired bite size or anatomical location were described. Surgeons expect to always achieve ratio 4:1 by taking two cm-bites of the abdominal wall with a continuous suture, and are reluctant to place stitches in the aponeurosis. Not only do surgeons fear that the aponeurosis is not strong enough to withstand tensile forces of the abdomen, the placement of many stitches in the aponeurosis is also assumed to inflict local necrosis. This study shows that the aponeurosis is strong enough to hold sutures. Furthermore, Cengiz et al. have described the benefits of small bites in several studies: better wound healing, no separation of wound edges and less trauma of abdominal muscles.[26-28] These effects could not be established in this study due to the use of devitalized abdominal walls. However, no good alternatives are available to analyze and measure tensile forces and types of dehiscence in the clinical situation.

Our experiments show that the use of the small stitch technique might have clinical advantages. Experience of the individual surgeon with this technique will influence the eventual result. In patients with midline laparotomy, using small bites with small suture distances may prove the best strategy. Randomized clinical trials should be performed to provide convincing data to support a change of technique.

Conclusion

Small bites with small suture distances achieve higher tensile forces than large bites with large suture distances in our porcine in-vitro model. Large bites should only be used when high SL:WL ratios are achieved in order to achieve acceptable tensile strengths. Small bites with small suture distances are recommended to easily achieve high SL:WL ratios and higher tensile strengths. Therefore, small bites may be useful to prevent development of burst abdomen and incisional hernia after midline incisions in patients.

References

1. Manninen MJ, Lavonius M, Perhoniemi VJ. Results of incisional hernia repair. A retrospective study of 172 unselected hernioplasties. The European journal of surgery = Acta chirurgica 1991;157(1):29-31.
2. Anthony T, Bergen PC, Kim LT, et al. Factors affecting recurrence following incisional herniorrhaphy. World J Surg 2000;24(1):95-100;discussion.
3. Paul A, Korenkov M, Peters S, Kohler L, Fischer S, Troidl H. Unacceptable results of the Mayo procedure for repair of abdominal incisional hernias. The European journal of surgery = Acta chirurgica 1998;164(5):361-7.
4. Read RC, Yoder G. Recent trends in the management of incisional herniation. Arch Surg 1989;124(4):485-8.
5. Augestad KM, Wilsgaard T, Solberg S. [Incisional hernia after surgery for abdominal aortic aneurysm]. Tidsskr Nor Laegeforen 2002;122(1):22-4.
6. Weiland DE, Bay RC, Del Sordi S. Choosing the best abdominal closure by meta-analysis. American journal of surgery 1998;176(6):666-70.
7. van 't Riet M, Steyerberg EW, Nellensteyn J, Bonjer HJ, Jeekel J. Meta-analysis of techniques for closure of midline abdominal incisions. The British journal of surgery 2002;89(11):1350-6.
8. Rucinski J, Margolis M, Panagopoulos G, Wise L. Closure of the abdominal midline fascia: meta-analysis delineates the optimal technique. The American surgeon 2001;67(5):421-6.
9. Ceydeli A, Rucinski J, Wise L. Finding the best abdominal closure: an evidence-based review of the literature. Current surgery 2005;62(2):220-5.
10. Hodgson NC, Malthaner RA, Ostbye T. The search for an ideal method of abdominal fascial closure: a meta-analysis. Annals of surgery 2000;231(3):436-42.
11. Wissing J, van Vroonhoven TJ, Schattenkerk ME, Veen HF, Ponsen RJ, Jeekel J. Fascia closure after midline laparotomy: results of a randomized trial. The British journal of surgery 1987;74(8):738-41.
12. Corman ML, Veidenheimer MC, Coller JA. Controlled clinical trial of three suture materials for abdominal wall closure after bowl operations. American journal of surgery 1981;141(4):510-13.
13. Israelsson LA, Jonsson T. Suture length to wound length ratio and healing of midline laparotomy incisions. The British journal of surgery 1993;80(10):1284-6.
14. Israelsson LA, Jonsson T. Incisional hernia after midline laparotomy: a prospective study. The European journal of surgery = Acta chirurgica 1996;162(2):125-9.
15. Israelsson LA, Jonsson T. Overweight and healing of midline incisions: the importance of suture technique. The European journal of surgery = Acta chirurgica 1997;163(3):175-80.
16. Sanders RJ, DiClementi D. Principles of abdominal wound closure. II. Prevention of wound dehiscence. Arch Surg 1977;112(10):1188-91.
17. Adamsons RJ, Musco F, Enquist IF. The chemical dimensions of a healing incision. Surgery, gynecology & obstetrics 1966;123(3):515-21.
18. Campbell JA, Temple WJ, Frank CB, Huchcroft SA. A biomechanical study of suture pullout in linea alba. Surgery 1989;106(5):888-92.
19. Carlson MA. Acute wound failure. The Surgical clinics of North America 1997;77(3):607-36.
20. Ellis H, Bucknall TE, Cox PJ. Abdominal incisions and their closure. Current problems in surgery 1985;22(4):1-51.
21. Hogstrom H, Haglund U, Zederfeldt B. Suture technique and early breaking strength of intestinal anastomoses and laparotomy wounds. Acta chirurgica Scandinavica 1985;151(5):441-3.
22. Rodeheaver GT, Nesbit WS, Edlich RF. Novafil. A dynamic suture for wound closure. Annals of surgery 1986;204(2):193-9.
23. Pollock AV, Evans M. Early prediction of late incisional hernias. The British journal of surgery 1989;76(9):953-4.
24. Pollock AV, Greenall MJ, Evans M. Single-layer mass closure of major laparotomies by continuous suturing. Journal of the Royal Society of Medicine 1979;72(12):889-93.

25. Israelsson LA. Incisional hernias in patients with aortic aneurysmal disease: the importance of suture technique. Eur J Vasc Endovasc Surg 1999;17(2):133-5.
26. Cengiz Y, Blomquist P, Israelsson LA. Small tissue bites and wound strength: an experimental study. Arch Surg 2001;136(3):272-5.
27. Cengiz Y, Gislason H, Svanes K, Israelsson LA. Mass closure technique: an experimental study on separation of wound edge. The European journal of surgery = Acta chirurgica 2001;167(1):60-3.
28. Cengiz Y, Israelsson LA. [Closure of midline incisions. A lot of small, same-size stitches in the aponeurosis improve wound healing]. Lakartidningen 2002;99(24):2742-4.
29. Chan RW, Tize IR. Effect of postmortem changes and freezing on the viscoelastic properties of vocal fold tissues. Annals of biomedical engineering 2003;31(4):482-91.
30. van Os JM, Lange JF, Goossens RH, et al. Artificial midline-fascia of the human abdominal wall for testing suture strength. Journal of materials science 2006;17(8):759-65.
31. Jenkins TP. The burst abdominal wound: a mechanical approach. The British journal of surgery 1976;63(11):873-6.