

Abdominal wound closure: current perspectives

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Abstract: This review examines both early and late wound complications following laparotomy closure, with particular emphasis on technical aspects that reduce hernia formation. Abdominal fascial closure is an area of considerable variation within the field of general surgery. The formation of hernias following abdominal wall incisions continues to be a challenging problem. Ventral hernia repairs are among the most common surgeries performed by general surgeons, and despite many technical advances in the field, incisional hernia rates remain high. Much attention and research has been directed to the surgical management of hernias. Less focus has been placed on prevention of hernia formation despite its obvious importance. This review examines the effects of factors such as the type of incision, suture type and size, closure method, patient risk factors, and the use of prophylactic mesh.

Keywords: incisional, abdominal, hernia, prevention, wound closure techniques

Introduction

Despite many advances in surgical techniques, equipment, and supplies, complications after abdominal wall closure remain a persistent problem. The ideal abdominal closure should be efficient, provide strength, and serve as a barrier to infection. It should have low rates of fascial dehiscence, infection, hernia formation, suture sinus formation, and incisional pain. There are many technical considerations and patient factors that may help prevent these complications. For this review, a MEDLINE search was performed. Articles related to abdominal fascial closure from 1952–2015 were used for this review.

Healing of abdominal incisions is similar to healing of other wounds. The inflammatory phase lasts approximately 4 days, followed by the proliferative phase for 3 weeks.^{1–4} The maturation phase continues for up to a year.^{1–4} By the end of the proliferative phase, the abdominal fascia has only 20% of its original strength.^{1–4} At 6 and 20 weeks postsurgery, the fascia has only 50% and 80% of its original strength, respectively. Postoperatively, abdominal fascia will never completely regain its original strength.^{1–4}

There is a large body of literature regarding the choice of incision and closure technique. Several patient risk factors are associated with increased dehiscence, wound complications, and hernia formation. Factors related to wound complications and incisional hernia formation and strategies to decrease their occurrence will be reviewed.

Type of incision

The type of operation and surgeon preference greatly influence the choice of abdominal incision. Vertical midline, lateral paramedian, and transverse incisions are the

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most common types of abdominal incisions. Prospective trials have shown vertical midline incisions to have hernia rates of 5%–15%.^{5–7} Lateral paramedian incisions have been reported to have incisional hernia rates of less than 1%.⁸ Three separate randomized trials, which included a broad range of general surgical procedures, compared lateral paramedian and midline incisions. All three demonstrated the superiority of paramedian incisions with regard to hernia formation with equivalent rates of wound infection.^{9–11} Despite the apparent benefits of the paramedian incision, it has not gained widespread use. This is likely due to the challenge of ostomy creation, slower entrance and closure, and decreased exposure compared with a midline laparotomy.

Several randomized studies have compared midline incisions with transverse incisions. Greenall et al¹² randomized 579 patients to either the midline or transverse incision groups and reported no differences in postoperative hernias between the two groups. Seiler et al¹³ randomized 200 patients to midline or transverse incisions in major elective abdominal surgery and also reported no difference in mortality, pulmonary complications, length of hospital stay, and incisional hernia formation at 1 year. Conversely, Halm et al¹⁴ reported that midline incisions resulted in significantly more incisional hernias. A 2005 Cochrane review concluded that there was no difference in incisional hernia rates or other complications among patients undergoing midline compared with transverse incisions.¹⁵

Suture type and continuous versus interrupted abdominal wall closure

There has been much research and debate over the type of suture material that should be used in abdominal closures. Nonabsorbable, slowly absorbable, and rapidly absorbable sutures can be used for fascial closure. These sutures can be either monofilament or multifilament. Multifilament sutures have greater tensile strength for a given size;¹⁶ however, they cause greater tissue reactivity and are more prone to infection and sinus formation.¹⁶ It is thought that bacteria can be harbored within the filaments of a multifilament suture.¹⁷ Consequently, monofilament sutures are traditionally favored for abdominal closure.¹⁸ Ultimately, the choice of optimal sutures depends on the outcome that is being evaluated, with less hernia formation associated with permanent suture but increased infectious wound complications compared with the absorbable suture.

Several randomized trials and meta-analyses have examined continuous versus interrupted closures. Continuous closure is typically recommended over interrupted closure,

since it is faster and less costly. Dehiscence, wound complication rates, and incisional hernia rates are similar between interrupted and continuous closures. There is a theoretical benefit of even distribution of tension across the entire incision with continuous sutures.^{19,20} A potential disadvantage of a continuous closure is the risk that the entire suture line can be disrupted if a single knot or strand of suture breaks; however, this has proven to be an extremely rare cause of wound dehiscence.^{21,22} This potential disadvantage can be overcome if a self-locking knot is employed instead of a traditional knot. Self-locking knots are smaller and less likely to slip than conventional knots. Additionally, self-locking knots reduce the suture strength by only 5%–10%, compared with a 40% reduction caused by traditional knots.²³

In a meta-analysis by Hodgson et al,²⁴ continuous closure with nonabsorbable sutures resulted in the lowest rate of incisional hernia. The analysis also showed that polydioxanone (PDS), unlike other more rapidly absorbable sutures, did not significantly increase the risk of hernia. Meta-analyses by Diener et al²⁵ and Van't Riet et al²⁶ demonstrated no difference in incisional hernia incidence between slowly absorbable and nonabsorbable sutures; however, more wound pain and more suture sinuses occurred with the use of nonabsorbable sutures. Similar outcomes were observed with continuous and interrupted sutures, but continuous sutures took less time to insert. There is little literature regarding the optimal closure technique of emergent laparotomies with significant contamination. A randomized trial of patients undergoing laparotomy for peritonitis by Agrawal et al²⁷ showed no significant difference in incisional hernia formation between the absorbable and nonabsorbable suture. However, the study showed significantly more sinus formation with the use of nonabsorbable sutures.²⁷

Retention sutures have fallen out of favor and are rarely used in current general surgery practice. The presumed strength benefits of passing the suture through the skin and the entire abdominal wall have not borne out. They are associated with increased postoperative pain and do not decrease the incidence of fascial dehiscence.²⁸

Suture-to-wound-length ratio and suture size

The amount of suture used also appears to be important in reducing hernia formation.²⁹ A suture-to-wound-length ratio of at least 4:1 is thought to be the minimum amount of suture needed to provide a strong closure and reduce hernia formation.^{18,30} There are little randomized data to support this assertion; however, a threefold increased risk of herniation

has been reported when the ratio is less than 4:1.^{31,32} It is not clear with what frequency a 4:1 suture-to-wound-length ratio is obtained in clinical practice, since most surgeons do not routinely measure their exact suture usage.

One factor that affects the suture-to-wound-length ratio is the size and distance between the fascial bites. Some have questioned the traditional teaching that fascial bites should be 1 cm from the fascial edges and have 1 cm advances.³³ This is likely not the ideal closure method. Several studies from Israelsson et al have reported that a 4:1 ratio for suture-to-wound length and smaller fascial bites (<1 cm) result in less hernia formation.^{29,32,34–37} Larger bites contain and compress more soft tissue. Two recent randomized trials by Millbourn et al³⁶ and Deerenberg et al³⁸ comparing fascial closure using smaller bites (5–8 mm) to larger bites (10 mm) demonstrated decreased incisional hernias when smaller fascial bites were used.^{36,39,40} The use of smaller needles was found to encourage surgeons to take smaller bites as the smaller needles make taking larger bites more difficult.^{39,40} The use of smaller fascial bites to close prolonged each operation by an average of just 4 minutes; however, this was found to be cost-effective given the significant reduction in hernia formation.^{36,39,40} Cengiz et al³⁷ also demonstrated that a suture-to-wound-length ratio much greater than 4:1 did not increase wound complications.

Other closure techniques that affect the suture-to-wound ratio are mass closure versus closure of the aponeurosis only and the appropriate amount of tension to apply to the closing suture. A systematic review by Ceydeli et al concluded that mass closure should be used;⁴¹ however, an animal study in pigs showed more wound edge separation with mass closure compared with aponeurosis only.³⁵ The ideal amount of tension that should be placed on the closing suture remains unknown due to a lack of clinical research. One study by Mayer et al revealed that greater tension on the suture line increased the rate of wound infection compared with a lower suture line tension.⁴² It is thought that soft tissue caught in a tight stitch can become ischemic, increasing the risk of a wound infection and future hernia formation.⁴² There are reports of wounds closed with lower tension having an increased tensile strength compared with wounds closed with higher tension.^{4,43} Calculating and standardizing the amount of suture line tension remains a challenge clinically.²⁰ It is generally recommended that the tissue be reapproximated but not strangulated.²⁰ The tension of a midline closure is likely too high when the suture line is not visible due to being deeply embedded in the soft tissue.²⁰

The majority of surgeons and most studies use a number 1 or 0 sized suture for fascial closure. One study found no change in hernia formation when a 2-0 sized suture was used.⁴⁴ Millbourn et al³⁶ demonstrated a significantly lower rate of incisional hernia formation using 2-0 PDS taking small fascial bites.

There has been little research comparing fascial closure with double-loop suture compared with nonlooped suture. One study demonstrated an increased rate of pulmonary complications and death with double-loop suture.⁴⁵ This was possibly due to decreased abdominal wall compliance. Another prospective study found decreased rate of wound infection and dehiscence with the use of looped suture compared to nonlooped suture.⁴⁶ Given the conflicting results, further research is needed to draw any well-founded conclusions.

A single-layer mass closure technique includes all layers of the abdominal wall except the skin.⁴⁷ Experimental studies report a higher wound bursting strength and a lower rate of wound dehiscence when a mass closure is used compared with a layered closure.^{48–50} The inclusion of the peritoneum in the suture has no impact on wound strength, the rate of wound dehiscence, or incisional hernia; however, it may increase the formation of adhesions.^{51,52} A Cochrane review examining five trials comparing parietal peritoneal closure compared with no parietal peritoneal closure did not find any evidence for short- or long-term advantage in peritoneal closure.⁵³ Two meta-analyses favor the single-layer mass closure over layered closure.^{18,54} There is little data directly comparing the mass closure technique to the single-layer closure of the aponeurosis.⁴⁷ However, the recently published European Hernia Society guidelines on the closure of abdominal wall incisions under their weakest level of evidence recommended single layer closure of the aponeurosis.⁴⁷

Patient risk factors

Demographic risk factors for dehiscence and incisional hernia are similar. These risks include obesity, advanced age, male sex, smoking, diabetes mellitus, malnutrition, malignancy, and steroid use.^{48,55–63} These factors may contribute to delayed wound healing and decreased collagen synthesis.^{64–66} The effect of interventions focused on modifiable risk factors such as smoking and obesity remain a clinical challenge. Studies reporting the effect of weight loss and smoking cessation on the reduction of incisional hernia formation are lacking and likely reflect the difficulty of behavior modification.

Steroid or immunosuppressive therapy can have deleterious effects on wound healing, with patients undergoing liver transplantation reported to have incisional hernia rates of up to 23%.^{67,68} Another group at risk for incisional hernia are patients undergoing open repair of abdominal aortic aneurysm (AAA). Compared with patients undergoing laparotomy for aortoiliac occlusive disease, patients undergoing AAA repair have more than a threefold increase in the rate of incisional hernia formation.^{69,70} Relaparotomy is another strong risk factor for postoperative incisional hernia formation.^{65,71} This may be due to resuturing of relatively nonvascular scar tissue leading to insufficient healing.⁷¹

Postoperative wound infections are one of the most well-documented risk factors for early dehiscence and subsequent hernia formation.^{48,55,56,62,72} The proliferation of bacteria leads to decreased collagen synthesis and weakening of the fascial closure.^{73–75} Postoperative abdominal distention and respiratory failure are also major risk factors for dehiscence and hernia formation. Distention increases tension along the suture line, causing higher risk of suture breaking, knot slipping, and suture cutting through the fascia and soft tissue. Loosening of the suture and separation of the fascial edges can lead to incisional hernia formation.^{31,35,71,72}

Prophylactic mesh

The success of mesh use in decreasing hernia recurrence rates in patients undergoing inguinal and ventral hernia repairs has led some to consider prophylactic mesh placement in the high risk patient population.⁴⁷ As in all prophylactic therapy, it is important to select patients in whom the therapy has a significantly lower complication rate than the expected rate without the intervention.

Several reports in animal models and high risk patient populations have supported the use of prophylactic mesh.^{76–80} The use of prophylactic mesh has been studied in patients undergoing open AAA repair with significantly lower rates of incisional hernia reported without more complications.^{81,82} However, other studies have demonstrated low rates on incisional hernia formation after open AAA repair using no mesh but with careful adherence to the previously discussed closure techniques.^{83,84} Another area of active research is the use of prophylactic mesh in ostomy creation due to the high rate of parastomal hernias. A significantly lower rate of parastomal hernias with no increase in complication rates was noted in two recent systematic reviews.^{85,86}

Evidence supporting the use of prophylactic mesh in high risk patient populations is building. However, further study with longer follow-up is needed. Questions regarding

the role of biologic mesh, placement techniques, and which populations would benefit the most remain unanswered and are areas of active research.

Conclusion

Decreasing local wound complications and incisional hernia formation after abdominal wound closure remains a persistent challenge. Yet there is a considerable amount of evidence regarding the optimal closure technique. While the type of incision seems to play a role in hernia formation, surgeons, who are typically focused on the operation at hand, are unlikely to change their practice.

To decrease local wound complications and hernia formation after laparotomy closure, fascial closure with a size 1 or 2 slowly absorbable monofilament suture should be used. It should be closed in one layer in a continuous manner with self-locking anchor knots. The suture length-to-wound-length ratio should be greater than 4:1. Closure should be accomplished with small fascial bites (5–8 mm). Excessive tension should be avoided. Obtaining the appropriate ratio and smaller fascial bites can more easily be done if a smaller suture and needle are used. The use of prophylactic mesh in certain high risk patient populations is a reasonable consideration.

The described optimal closure techniques are easy to follow and cost-effective. The current focus should be on obtaining widespread adoption to improve patient outcomes. A recent study evaluating surgery residents found that only 10% of residents knew the correct suture-to-wound-length ratio, and only 40% were familiar with literature on the proper technique of abdominal closure.⁸⁷ Thus, if incisional hernia rates are to be decreased, education regarding current best practices of abdominal closure needs to be addressed.

Disclosure

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