Finding the Best Abdominal Closure: An Evidence-based Review of the Literature

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BACKGROUND: Despite advances in surgical technique and materials, abdominal fascial closure has remained a procedure that often reflects a surgeon's personal preference with a reliance on tradition and anecdotal experience. The value of a particular abdominal fascial closure technique may be measured by the incidence of early and late wound complications, and the best abdominal closure technique should be fast, easy, and cost-effective, while preventing both early and late complications. This study addresses the closure of the vertical midline laparotomy incision.

DATA SOURCES: A MEDLINE (National Library of Medicine, Bethesda, Maryland) search was performed. All articles related to abdominal fascia closure published from 1966 to 2003 were included in the review.

CONCLUSIONS: Careful analysis of the current surgical literature, including 4 recently published meta-analyses, indicates that a consistent conclusion can be made regarding an optimal technique. That technique involves *mass closure*, incorporating all of the layers of the abdominal wall (except skin) as 1 structure, in a *simple running technique*, using #1 or #2 *absorbable monofilament* suture material with a *suture length to wound length ratio* of 4 to 1. (Curr Surg 62:220-225. © 2005 by the Association of Program Directors in Surgery.)

KEY WORDS: abdominal closure, suture material, suture size, layered closure, mass closure, continuous closure, interrupted closure

INTRODUCTION

Despite advances in surgical technique and materials, abdominal fascial closure has remained a procedure that often reflects a surgeon's personal preference with a reliance on tradition and anecdotal experience. Several theoretical and practical facts have been described about operative site healing and include the physiology of fascial healing, the physical properties of specific closure methods, the properties of the available suture materials, and patient-related risk factors.[1,2] Yet the ideal techniques and materials, although suggested by the surgical literature, have not been uniformly accepted.

The value of a particular abdominal fascial closure technique may be measured by the incidence of early and late wound complications. Early complications include wound dehiscence (sometimes associated with evisceration) and infection, whereas late complications are hernia, suture sinus, and incisional pain.

The best abdominal closure technique should be fast, easy, and cost-effective, while preventing both early and late complications. Traditionally, individual authors have advocated 1 technique over another for theoretical or practical reasons, but until recently, evidence-based principles have not been applied to the subject as a whole. Relevant factors for review include (1) layered closure, mass closure, and retention sutures; (2) continuous closure and interrupted closure; (3) suture material, and (4) suture thickness and the suture length-to-wound length ratio. Careful analysis of the current surgical literature, with the identification of evidence-based conclusions, indicates that a relative consensus exists regarding the most effective method of midline abdominal fascial closure.

METHODS

A MEDLINE (National Library of Medicine, Bethesda, Maryland) search was performed. All articles related to abdominal fascia closure published from 1966 to 2003 were included in the review.

DISCUSSION

There were 4 *complications* involved in comparison of the different techniques of fascial closure apparent on review of the literature:

Early Complications

1. Fascial dehiscence

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2. Infection

Late Complications

3. Hernia formation
4. Suture sinus/Incision pain

These 4 complications are derived from a consensus of the articles upon which the review is based. That is to say the various techniques are compared in each article that is cited on the basis of 1 or more of these 4 complications.

Layered Closure, Mass Closure, and Retention Sutures

Layered closure is described as the separate closure of the individual components of the abdominal wall, specifically the peritoneum and the distinct musculo-aponeurotic layers. *Mass closure* is the closure of all layers of the abdominal wall (except the skin) as 1 structure.

Layered closure, often in conjunction with a paramedian incision, is a technique that was viewed as essential to adequate and appropriate wound closure in the past. Discussion of the paramedian incision, however, has disappeared from current surgical writing and it is little used in practice. The proponents of layered paramedian closure believed that the approach reduced intraperitoneal adhesions, contributed to wound strength, discouraged dehiscence, prevented leakage of intraperitoneal contents, and promoted hemostasis.[3-8]

Smead first described a mass closure technique in 1900. Jones described the same technique in 1941, and thereafter it was called the Smead-Jones technique. Dudley, in an experimental study in 1970, showed that mass closure was superior to layered closure when using stainless steel wire.[9] In 1975, Golligher supported the concept of mass closure by demonstrating a dehiscence rate of 11% with layered fascial closure compared with a rate of 1% with mass closure. (It should be noted, however, that chromic catgut, with its own inherent reasons for wound failure, was used for layered closure and was compared with stainless steel wire for mass closure.)[10] In 1982, Bucknall et al prospectively studied 1129 abdominal operations and demonstrated that layered closure was associated with a significantly higher dehiscence rate compared with mass closure (3.81% vs. 0.76%).[11]

Subsequent investigators, further questioning the beneficial effects of layered closure, compared it with mass closure techniques producing a number of conclusions favoring the latter. Peritoneal closure, specifically, has been shown to be associated with an increased incidence of adhesions, compromise of the adequacy of closure of the subsequent layers, and increased duration of operation.[12-25] Recently published meta-analyses have confirmed a statistically significant reduction in hernia formation and dehiscence with mass closure.[26-28]

Retention sutures (involving the entire thickness of the abdominal wall including the skin and subcutaneous tissue) were first described by Reid in 1933 but have lost much of their popularity in recent years. It has been shown that the additional security of retention sutures is largely hypothetical, that they are associated with increased postoperative pain, and that they make site determination of enteral stomas difficult.[13] In addition, retention sutures have not been shown to decrease the incidence of fascial dehiscence.[13]

Continuous Closure and Interrupted Closure

Multiple reports show no difference in the incidence of dehiscence or hernia formation when either technique is used.[29-32]

Proponents of continuous closure cite an evenly distributed tension throughout the length of the incision and a more cost-effective closure requiring half as much time and less suture material as definite advantages of continuous mass closure.[26,29-38] It has also been shown experimentally that the bursting strength of a wound is significantly higher when a continuous closure is used by surgeons.[39,40] Continuous closure minimizes the number of knots and has been shown to be associated with an equivalent or lower incisional hernia rate in 4 meta-analyses.[26-28,41] The only theoretical disadvantage of continuous closure is that the security of the wound is dependent on a single strand of suture material and a limited number of knots. Disruption of the knot or the suture, however, has been shown to be a rare cause of wound dehiscence.[33,42]

Suture Material

Nonabsorbable, slowly absorbable, and rapidly absorbable suture materials are available. In addition, such materials are available in monofilament and multifilament (braided) form. The choice of material for closing the abdominal fascia should be made in the light of what is known about fascial healing and the physical properties of suture material (strength, durability, ease of handling, and resistance to infection).[43] It was demonstrated in the early 1950s that the healing process of abdominal fascia after surgical incision continues for 9 to 12 months.[44,45] Abdominal fascia regains only 51% to 59% of its original tensile strength at 42 days, 70% to 80% at 120 days, and 73% to 93% by 140 days. Tensile strength never rises to higher than 93% of the strength of unwounded fascia.[44,45]

Nonabsorbable materials have been widely used for abdominal fascial closure since the 1970s. The most common nonabsorbable materials used are polypropylene (Prolene: Ethicon, Inc, NJ), nylon (Nurolon: Ethicon, Inc, NJ), polyethylene (Ethibond: Ethicon, Inc, NJ), and polyamide (Ethilon: Ethicon, Inc, NJ).[46] Stainless steel wire and silk are only of historical note and are infrequently used by surgeons in current surgical practice. Stainless steel is difficult to handle and tie and tends to develop fractures. Braided silk is a long-lasting biomaterial but is associated with a rapid loss of tensile strength (similar to absorbable sutures), a high association with infection, and an intense inflammatory reaction.[48-50] Other braided nonabsorbable suture materials have much better tensile strength charac-

teristics but are less resistant to infection than nonabsorbable monofilament or absorbable materials.[48-50]

Nonabsorbable monofilament suture materials have been shown to have more tissue reactivity than stainless steel, but less than absorbable sutures. They are more resistant to infection than absorbable sutures, but their use is associated with a higher incidence of sinus formation, wound pain, and button-hole hernia.[47-54] (A button-hole hernia develops lateral to the main incision in association with progressive enlargement of the needle hole through which the permanent suture material passes.) The benefits of nonabsorbable materials lie in the fact that they retain their strength as the fascia develops intrinsic strength in the process of wound healing.

Absorbable materials are designed to approximate the fascia during the critical early healing period and subsequently to undergo absorption to avoid the complications of sinus formation, pain, and buttonhole hernia associated with nonabsorbable sutures. The incidence of chronic wound pain and suture sinus formation have been found to be significantly less with absorbable material.[28,47,52,53] Absorbable sutures may be classified as rapidly absorbable and slowly absorbable. Catgut, chromic catgut, polyglycolic acid, and polyglactin 910 are examples of rapidly absorbable materials.

In surgical practice, catgut and chromic catgut are no longer widely used by surgeons for fascial closure. Polyglycolic acid (Dexon: US Surgical and Davis & Geck, Inc., CT) and polyglactin 910 (Vicryl: Ethicon, Inc., NJ) are the most commonly used rapidly absorbable suture materials by surgeons. Absorption of such materials lasts 15 to 90 days, although most of their tensile strength is lost in 14 to 21 days.[46] Dexon and Vicryl are braided materials but are less reactive than silk or catgut because they are absorbed by hydrolysis. Their absorption may be delayed by infection, and they may act as a focus for infection and as a foreign body with an associated delay in healing.[26-28,41,49] The rapidly absorbable suture materials have been associated with increased rates of incisional hernia formation when compared with nonabsorbable sutures.[28,46,47]

Polydioxanone (PDS: Ethicon, Inc., NJ) and polyglyconate (Maxon: US Surgical and Davis & Geck, Inc., CT) are the most commonly used slowly absorbable suture materials by surgeons. Absorption of such materials takes about 180 days, and they maintain 50% of their tensile strength for about 4 weeks.[46,56-61] PDS has been shown to have 1.7 times the tensile strength of Prolene. Maxon, the newest of the synthetic absorbable materials, has been shown to be 16% stronger than Vicryl.[39] PDS and Maxon are more similar to nonabsorbable materials than are Vicryl and Dexon in that they retain their strength for a longer period during fascial healing. They are absorbed slowly by hydrolysis and are not subject to enhanced absorption by bacterial enzymatic activity. Several studies, including 4 meta-analyses, have shown no statistically significant difference in the incidence of incisional hernia formation, wound dehiscence, or infection between the slowly absorbable and the nonabsorbable suture materials.[26-28,41] In contrast, in prospective studies as well as meta-analyses, nonabsorbable suture materials have been associated with statistically higher rates of incision pain and suture sinus formation.[28,41,44,47,52,53]

Suture Size and Suture Length-to-Wound Length Ratio

The mechanical reasons for wound dehiscence are as follows: (1) the suture breaks, (2) the knot slips, or (3) the suture cuts through the tissues. Generally the first 2 reasons are rare, and wound dehiscence occurs when the suture material tears through the fascia. The strength of a particular suture material increases as its cross-sectional diameter increases and smaller diameter sutures are associated with a greater likelihood of tearing through the tissue.[32,33,42,62,63]

Most of the studies in the current surgical literature employ a number 0 or larger size suture to close the fascia. It should be noted, however, that 1 series found no greater incidence of wound dehiscence, compared with studies in which surgeons use heavier gauge sutures, when they used size 2-0 suture material to close the fascia.[52] The double-loop closure method provides the most tensile strength, but in 1 study, it was associated with a significantly increased rate of pulmonary complications and postoperative death, possibly related to decreased compliance of the abdominal wall.[64] The suture thickness chosen, then, must provide adequate tensile strength as well as adequate elasticity to accommodate an increase in intra-abdominal pressure in the postoperative period.

The suture length-to-wound length ratio involves a geometric approach that aims to avoid wound dehiscence and hernia formation. It has been shown experimentally by Jenkins that the length of a midline laparotomy incision can increase up to 30% in the postoperative period in association with several factors that increase the intra-abdominal pressure.[65] If the bites taken in suturing (and the associated length of suture material used by surgeons) are not large enough to accommodate the potential increase in wound length, then the suture may cut through the fascia resulting in wound dehiscence. Jenkins, using the principles of geometry and the rules that apply to the component sides of triangles, studied the relationship of the bites of tissue taken in suturing to the amount of suture material used by surgeons. He concluded that the bite of tissue needed to avoid suture pull-through could be expressed in the length of suture material needed for the incision under consideration. In the study, it was determined that a suture length-to-wound length ratio of 4:1 would incorporate a large enough bite of tissue such that suture pull-through could not occur even with maximal lengthening of the incision in the postoperative period.[65-67] The 4:1 suture length-to-wound length ratio was achieved in Jenkins' study by placing the sutures approximately 2 cm away from the fascial edge and approximately 2 cm from one another.

SUMMARY

Analysis of 4 components of technique, which became apparent on review of the literature, allow one to conclude that a distinct set of technical components are superior in comparison with others:

1. *Mass closure* (compared with layered closure), supported by the referenced prospective studies as well as 3 meta-analyses.[26-28]
2. *Simple running technique* (compared with interrupted technique), supported by the referenced prospective studies as well as 4 meta-analyses.[26-28,41]
3. *Absorbable monofilament suture material* (compared with nonabsorbable monofilament and absorbable braided material), supported by meta-analysis.[28]
4. *Suture length to wound length ratio of 4:1*, supported by prospective experimental and clinical studies.[65-67]

CONCLUSION

The best abdominal closure technique should be fast, easy, and cost-effective while preventing both early and late complications. The *early* complications that are to be avoided are wound dehiscence and infection, and the *late* complications to be avoided are hernia, suture sinus, and incisional pain. Careful analysis of the current surgical literature, including 4 recent meta-analyses, indicates that an optimal technique exists. The most effective method of midline abdominal fascial closure involves *mass closure*, incorporating all of the layers of the abdominal wall (except skin) as 1 structure, in a *simple running technique*, with #1 or #2 *absorbable monofilament* suture material with a *suture length to wound length ratio* of 4 to 1.

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