Abdominal Wound Closure

A Randomized Prospective Study of 571 Patients Comparing Continuous vs. Interrupted Suture Techniques

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A randomized, prospective study was designed to compare a continuous with an interrupted technique for closing an abdominal incision. Five hundred seventy-one patients were randomized between the closure methods and stratified as to type of wound: clean, clean-contaminated, or contaminated. In midline incisions, the dehiscence rate was 2.0% (5/244) for the continuous group versus 0.9% (2/229) for the interrupted group. The difference was not statistically significant. Ventral hernias formed in 2.0% (4/201) of the continuous group *vs.* 0.5% (1/184) of the interrupted group. The type of wound had no influence on the results. In oblique incisions, 0% (0/39) of wounds closed continuously dehised while 2% (1/50) of incisions closed interruptedly dehised. No ventral hernias formed. Further analysis of the data indicated that dehiscence was more likely related to improper surgical technique than to the method of closure. An abdominal incision could be closed with a continuous suture in approximately half the time required for placing interrupted sutures (20 *vs.* 40 minutes). A continuous closure is preferred because it is more expedient and because it has the same incidence of wound disruption compared with an interrupted closure.

SECURE WOUND CLOSURE is an essential requirement for an uncomplicated and expedient recovery after an abdominal operation. The incidence of dehiscence ranges from 0 to 6% in different patient series and the associated mortality rate ranges from 10 to 35%.[1-11] This postoperative complication has been related to advanced age, anemia, hypoproteinemia, use of steroids, azotemia, malnutrition, malignant neoplasms, infection, type of operation, type of incision, method of closure, and type of suture material used.[2,7,10,12] Under usual circumstances, many of these factors are uncontrollable. Several studies have retrospectively examined how the type of incision, the method of closure, and the suture material employed have affected the incidence of wound dehiscence in a given surgical practice.[1,3,5,6,9,11] However, only a few clinical studies are available that are prospective and randomized and that are controlled for such variables as type of incision, method of closure, and suture material used.[4,8]

The best method of wound closure would be one that provides adequate tensil strength to the incision until the wound is healed, approximates the tissue in a way that normal healing mechanisms can occur under optimal circumstances, remains secure even in the presence of local or systemic infection, the suture material is well tolerated on a short- and long-term basis, and, finally, should be able to be done with expediency. Most techniques of incisional closure have used interrupted sutures.[4-6,9] Recently, several authors have used a continuous suture as an alternative method to close abdominal incisions.[1,8,11,12] The continuous suture has the advantages of an evenly distributed tension across the suture line and being more expedient; it has the disadvantage of being a single suture line holding the fascia together. The multiple interrupted suture method has been used successfully for many years, but has the disadvantages of being time-consuming to perform and of isolating the tension to each individual stitch.

This study was designed to compare, in a prospective randomized fashion, these two methods of abdominal wound closure (interrupted and continuous suture). The results were assessed by evaluating the influence of these two techniques on the rate of dehiscence or hernia formation after celiotomy incisions.

Methods

Patient Population

Only patients who had a abdominal incision greater than 5 cm were admitted into the study. They were

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stratified according to the following classification of their incision: *clean*, where the gastrointestinal or genitourinary tracts were not entered; *clean contaminated*, where the gastrointestinal or genitourinary tracts were entered, including elective operations in the biliary tract and intestine; *grossly contaminated*, where gross intraperitoneal soilage by intestinal contents or purulent exudate were found, or operations on an unprepared colon.

Randomization

At the time of wound closure, the senior surgeon decided if the patient qualified for entry into the study. The wound was classified and a sealed envelope was drawn from a box labeled as either clean, clean-contaminated, or grossly contaminated. The card directed whether the continuous or interrupted method of closure was to be used. Equal number of cards for each method of closure were randomly allocated to each box.

Follow-up

Once entered into the study, patients were followed for their hospital stay and for a minimum of 12 months to determine the incidence of incisional hernia formation. A patient was excluded from study when dehiscence occurred, hernia developed, or reoperation was required. Patients were considered lost to follow-up only if the status of the wound was not known at 12 months. If a patient expired with satisfactory healing of the incision, the patient was considered as part of the study group at 12 months. Each incision was specifically followed and investigated for hematoma, infection, dehiscence, evisceration, and hernia occurrence.

Factors Analyzed

All patients were analyzed as to sex, age, whether incision was primary or secondary, vertical or transverse, level of serum albumin, use of antibiotics, and length of hospital stay. Secondary incisions were those incisions made through previously well-healed incisions. All elective colonic cases underwent a vigorous mechanical preparation as well as oral antibiotic preparation with neomycin and erythromycin. The use of systemic antibiotics was not controlled and was left to the discretion of each surgeon.

Operative Techniques

The methods of incisional closure were as follows. The peritoneum was not closed as a separate layer. In the vertical incisions, the continuous technique consisted of using 0 polypropylene (Prolene®) placed at least 1.5 cm from the fascia edge and 1.0 cm between each suture. A strand of suture was started at each end of the incision placing the knots underneath the fascia, and then each suture was run toward each other and tied in the middle of the incision. In long incisions, three or more segments of continuous sutures were needed.

The interrupted technique consisted of placing 0 polygycolic acid sutures (Dexon®) at least 1.5 cm from the fascial edge and 1.0 cm apart. The Smead–Jones[6] far-far, near-near suture technique was used. In oblique or transverse incisions, the continuous technique consisted of two layers; the deep included the peritoneum and posterior rectus facial sheet, transversalis muscle layer, and the internal oblique musculoaponerotic layer was closed with one continuous Prolene as described above. The superficial layer incorporated the anterior rectus fascia and external oblique muscle closed with another continuous 0 Prolene suture. The interrupted technique was that described by Smead–Jones[6] with 0 Dexon being used. In both methods of closure, sutures were pulled or tied such that fascial edges were well approximated but not crushed together.

Management of the subcutaneous tissue and skin was not controlled but left to the preference of each surgeon. Approximately 10% of the study population had either delayed primary closure of skin, subcutaneous catheters for irrigation, or antibiotics placed in the subcutaneous space.

Results

During the time frame of this study, there were 881 patients at both the University of Alabama Hospital and the Birmingham Veterans Hospital who underwent an abdominal operation for which the incision was greater than 5 cm. Five hundred ninety-one patients were randomized to alternative wound closure methods. The operations encompassed the entire spectrum of abdominal procedures including negative laporatomies for trauma, aortobifemoral grafting, total proctocolectomy, or repairs of perforated abdominal viscuous. The majority of cases were performed on an elective basis. Major abdominal trauma cases and heavily contaminated cases were usually not entered into this study. Twenty patients were eliminated due to protocol violations. Either the wrong suture material was used or abdominal wall retention sutures were placed in combination with the randomized fascial closure. Thus, 571 patients form the basis of this study.

Table 1 demonstrates the stratification of patients with regard to type of incision, type of wound, and method of closure. Essentially equal numbers of patients are present for each type of closure when subdivided by the type of wound and the incision. For midline incisions, upper, lower, and combined incision (xiphoid to pubis) had virtually the same results, so they were tabulated into a single group. The nine patients with a para-

TABLE 1. *Stratification of Patients as to Type and Location of Wound and Closure Technique*

	Clean		Clean-Contaminated		Contaminated	
	A	B	A	B	A	B
Midline	108	91	115	114	21	24
upper	68	55	81	76	10	8
lower	7	9	28	33	8	12
complete	33	27	6	5	3	4
Oblique		0	39	49	0	1
Paramedian	3	0	0	6	0	0
Total	111	91	154	169	21	25

A = Continuous closure.
B = Interrupted closure.

median incision were not analyzed in detail due to their small number.

Table 2 lists the characteristics of the patient population. The average age for the total study group was 50.4 years. Within wound classes, there was no statistical difference between the average ages. Each type of closure group had an essentially equal portion of male patients. The higher percentage of males was due to patient entry into the study from the Veterans Hospital. The number of patients who had a prior operation and who were re-explored through a previous incision was the same for each closure method. An albumin level of 3 mg/dl was used as an indicator of hypoproteinemia and malnourishment. This occurred in 8% of the study group, and the patients were evenly distributed in each closure group. Preoperative antibiotics were given prior to the time of incision, and majority of these patients had post-operative antibiotics for 48 hours. No one group had a greater number of patients on antibiotics. The hospital stay after operation was not significantly different for any closure group. Five point six per cent of patients were on high-dose steroids or had renal failure prior to operation. These patients were evenly distributed among the closure groups.

Fifteen of 571 patients (2.6%) expired within two weeks of operation. All incisions of these patients were intact and there were no wound problems. Another 13 patients expired within the first 30 days after operation. All of these wounds healed satisfactorily. The overall 30-day operative mortality was 4.9% (28/571) patients. Neither of the closure groups had a significantly greater number of patients expire within the first 30 days. The status of all the wounds was available at one month after operation. At six months, 13% (74/571) patients were lost and the status of the wound was not known. At 12 months, an additional 2.5% (14/571) of patients were not available for review. This loss of patients was equal in each closure group. Overall, 85% (485/571) of patients were followed for 12 months.

Twenty-three patients (4%) developed wound abscesses that required drainage. Three patients with wound hematomas required drainage and their wounds healed satisfactorily. Table 3 illustrates that the incidence of wound abscesses and hematomas occurred equally in both groups. Seven out of 473 (1.5%) of midline incisions disrupted. Clean wounds closed continuously had 1.9% (2/108) dehiscence and wound closed with interrupted technique had 1.1% (1/91). The differences were not statistically significant. For clean-contaminated wounds, the incidence of dehiscence for the continuous technique was 1.7% (2/115), and there were no dehiscences in the interrupted group 0% (0/114). In the contaminated group wound, there was 4.8% (1/21) dehiscence in the continuous group and 4.2% (1/24) eviscerations in the interrupted group. The overall incidence of wound disruption for all midline incisions closed with continuous method was 2.0% (5/244) while it was 0.9% (2/229) for incisions closed with interrupted technique. The rate of wound disruption between the two closure techniques was not significant ($p = 0.503$).

TABLE 2. *Population Characteristics as Related to Closure Technique*

	Midline						Oblique	
	Clean		Clean-Contaminated		Contaminated		Clean-Contaminated	
	A	B	A	B	A	B	A	B
Average age (years)	48.0	47.2	54.1	52.8	36.3	45.9	52.6	54.5
% Patients > 60	31.5	24.2	41.7	36.8	4.8	25.0	38.5	46
% Male	80.6	80.2	73.0	71.1	76.2	75.0	59	54
% 2nd incision	10.2	12.1	20.0	21.9	19.0	16.7	2.6	4.0
% ALB < 3.0	3.7	4.4	9.5	11.0	9.5	20.0	15.5	6.0
% Preop antibioties	65.7	64.8	86.1	77.2	100	100	35.9	48.0
# Days in hospital (Ave.)	12.0	12.4	14.5	12.9	11.3	17.5	9.9	10.0
% Patients on steroids/azotemia	7.4	7.7	2.6	7.9	0	16.1	2.6	0

A = Continuous closure. B = Interrupted closure.

TABLE 3. *Wound Status*

	Midline						Oblique	
	Clean		Clean-Contaminated		Contaminated		Clean-Contaminated	
	A	B	A	B	A	B	A	B
Abcess/hematoma	3/1	6/1	5/1*	4/0	2/1	3/0	—	—
Dehiscence/evisceration	2/0	1/0	2/0	0	1/0	0/1	0	1/0
Hernia early	2	0	1	1	0	0	0	0
Hernia late	1	0	0	0	0	0	0	0

* Fistula through wound—no dihiscence.
A = Continuous closure.
B = Interrupted closure.

Further analysis as to location of incision (Table 4) demonstrates that upper midline incisions did not have a greater frequency of wound disruption 1.7% (5/298) than the other midline incisions 1.7% (3/175). The location of the incision did not influence the incidence of dehiscence or evisceration. In oblique incisions, no continuous wound disrupted (0%) and only 2% (1/50) of the interrupted closure wounds disrupted. This is not significant at the p = 0.05 level. No patient on steroids or with renal failure had dehiscence or evisceration.

At 30 days postoperation no incisional hernias were present. At 6 months, 1.0% (4/385) patients with midline incisions developed hernias. The hernias occurred with equal frequency in each type of wound and each method of closure (Table 3). At 12 months only one new hernia developed. Table 4 demonstrates that the incidence of hernias was equal for all locations of wounds and closure of wounds. There was no significant increase in hernia formation in the continuous group 2.0% (4/201) *vs.* the interrupted group 0.5% (1/184). In oblique incisions no hernias developed at all. Three stitch abscesses developed in the continuous closed wounds that healed after removal of a prolene knot. No hernia developed in any patient with a wound infection or hematoma.

The eight cases in which dehiscence or evisceration occurred were reviewed to determine the etiology of this event. Five of cases were directly related to technical problems. In the three cases closed with the interrupted technique, the sutures pulled through the fascia on postoperative days 6, 7, and 10, respectively. In the two cases in which the continuous technique was used, the sutures had pulled through the fascia, and the fascia was described as being necrotic. The suture may have been placed too tightly during the closure. These dehiscences occurred on postoperative days 6 and 14. Three cases of dehiscence were associated with wound infection. All were closed with the continuous method. One patient had abdominal trauma and developed a pancreatic fistula through the incision. Another patient has a gastric bypass for obesity and developed a left subphrenic abscess that drained through the wound. The third patient with upper G.I. hemorrhage developed wound infection with dehiscence after surgery. Of the 13 patients closed with the interrupted technique who later had wound infection, there was no dehiscences of the incision. Of the ten patients closed with the continuous technique who had wound infection, 30% (3/10) patients developed a dehiscence. These differences were not statisti-

TABLE 4. *Wound Disruption Stratified to Wound Type and Location*

	Clean			Clean-Contaminated			Contaminated		
	A	B		A	B		A	B	
Midline dehiscence									
upper	1 (1.5%)	1 (1.8%)	p = N.S.	2 (2.5%)	0	p = N.S.	0	1 (12.3%)	p = N.S.
lower	0	0		0*	0		1 (12.5%)	1 (8.3%)	p = N.S.
complete	1 (3.0)	0	p = N.S.	0	0		0	0	
Total	2 (1.9%)	1 (1.1%)	p = N.S.	2 (1.7%)	0 (0%)	p = N.S.	1 (4.8%)	1 (4.2%)	p = N.S.
Hernia-upper	2 (3.0%)	0	p = N.S.	0	0		0	0	
lower	0	0		1	1	p = N.S.	0	0	
complete	1 (1.5%)	0	p = N.S.	0	0		0	0	
Total	3 (3.1%)	0 (0%)	p = N.S.	1 (0.9%)	1 (0.9%)	p = N.S.	(0%)	(0%)	

* Fistula, no wound disruption.
A = Continuous closure.
B = Interrupted closure.
N.S. = No significance.

cally different ($p = 0.134$). However, the 13% (3/23) incidence of dehiscence in infected wounds is statistically higher than the 0.9% (5/548) incidence in noninfected wounds ($p < 0.02$).

Discussion

In a group of patients that includes all major elective and urgent operations, this randomized, prospective study demonstrates that there is no difference in wound disruption in the immediate postoperative period between the continuous method of closure and the interrupted method of closure. The 2.0% (5/244) dehiscence rate for the continuous method is similar to other reports of continuous closure in which the incidence of disruption ranged from 0 to 2.8%.[1,3,8,11,12] The 0.9% (2/229) of dehiscence for the interrupted method is also comparable with other series of interrupted closure in which the incidence ranged from 0 to 4.0%.[4–6,9] Since the maintenance of wound integrity is similar, the main advantage of the continuous method is the amount of time that it takes to close an incision. Although the exact time to close an incision was not consistently recorded, the closing time for the continuous method was in the range of 20 to 25 minutes, while the time for interrupted technique was in range of 40 to 45 minutes. As emphasized by previous reports, this time factor is important to the patient in regard to hospital cost and the length of time under anesthesia.[8,11]

Overall, incisional hernias developed in 5/585 (1.3%) of patients and was independent of method of closure. Other reports of incisional hernia in incisions closed with interrupted sutures are 0 to 2.5%[6,7,9,10] and in incisions closed with the continuous technique are 0 to 4.3%.[1,3,6,8,11,12] None of these ventral hernias developed within 30 days after operation. By six months, 80% (4/5) of the hernias had occurred while only 20% (1/5) developed in the succeeding six months. The occurrence of most hernias within six months in consistent with other reports.[4,8,9,11] Neither method of closure prevented normal healing from occurring as demonstrated by the rate of ventral hernia formation.

Dudly[1] and Jenkins[12] have indicated that wound disruption is related to the size of tissue bite taken and the tightness that fasical edges are approximated. In the design of protocols for each method of closure, the importance of these studies has been emphasized. Tissue bites at least 1.5 cm from the fasical edge were required. Smaller bites were and are believed to be unsafe. Sutures were placed and tied such that fascial edges were well approximated but not compressed tightly together. In five of eight cases of dehiscence (three interrupted closures and two continuous closures) the sutures had pulled through fascia. Although the exact details are not known, the suture bites were either too small or the suture pulled too tightly or both. One criticism of continuous closure is that it may cause ischemia and/or necrosis of fascia with subsequent dehiscence. Following the protocol of this study, only two cases of this nature were noted. These cases represent failures in surgical technique rather than closure method. If these cases of dehiscence had been eliminated, the incidence or wound disruption would have been 0.005% (3/571). Proper surgical technique is the critical factor in any wound closure and the method of closure is only as effective as it is used.

Three cases of dehiscence occurred in the presence of wound infection. Two cases were associated with intra-abdominal infection or fisula that seemingly pointed through the incisions. It should be noted that one patient developed an intestinal fistula and wound infection in a continuously closed wound and the incision remained intact. Only one wound closed continuously disrupted secondary to a superficial wound infection. Although all these cases occurred in the continuous closed group, there was no statistical difference in dehiscence rate in infected wounds between either method of closure. Since the presence of infection is associated with a higher incidence of dehiscence,[2,7,10] emphasis to reduce dehiscence should be placed on prevention of infection rather than the method of closure. If infection develops, both methods of closure are secure. The suture material does not play a significant role because both methods have been shown to resist and retard the development of infection.[13] However, since Prolene is nonabsorbable, it may serve as foreign body that maintains a superficial sinus tract until it is removed. This occurred only three times in this study and was not a major problem. Attempts at burying the knot subfacially should be made to prevent this minor difficulty.

There was no objective way of evaluating patient tolerance to either closure method. All patients usually were ambulated on the first postoperative day and they tolerated this activity without major complaints. Review of the charts did not reveal any major patient discomfort regarding their incisions.

No ideal suture material is presently available but Polyproplene (Prolene®) and polygolic acid (Dexon®) are close to being ideal suture material.[13–15] Polyproplene was chosen for the continuous closure suture because of its tensile strength and inert properties. The main faults of Prolene are the necessity of many throws to secure a knot and its nonabsorbability. These factors are minimized by a continuous closure when few knots are required and the amount of suture present in the wound is as small as possible. Polygolic acid (Dexon®) was chosen for the interrupted technique because it is relatively easy to handle, it is absorbable, and for the security of its knots. Due to a question of maintaining

its tensile strength during healing,[14,15] a continuous closure using Dexon was believed to be unsafe. A recent study does not confirm this fear[11] and these results indicate that interrupted polygolic acid maintains fascial integrity well. The purpose of the study was not to compare the desirability of one suture material over another but to compare the techniques of interrupted *vs.* continuous fascial closure.

In summary, the best method of abdominal wound closure provides tensile strength, does not inhibit wound healing, does not promote wound infection, and is well tolerated by patients. Both closure methods used in this study meet these requirements. A randomized prospective comparison failed to demonstrate that an interrupted closure is superior to a continuous closure. The most important factor in preventing wound dehiscence is surgical technique. A continuous closure is preferred because of its relative ease and expedience as a means of closing an abdominal incision.

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