

Original Research Article

Comparative study of efficacy of modified continuous smead-jones versus interrupted method of midline laparotomy fascial closure for contaminated cases

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ABSTRACT

Background: Mass closure of midline laparotomy fascial wound is undoubtedly superior to layered closure technique. For elective surgeries continuous method is recommended over interrupted to avoid wound dehiscence, but controversy exists in the literature about the best method of midline fascial suturing in contaminated cases. Thus this is the study to compare two techniques of closure.

Methods: Prospective non-randomised study. Two groups are study group who underwent modified smead-Jones method of fascia closure and control group who underwent interrupted closure. Outcome parameters studied were time required for closure, length of suture material needed, postoperative wound infection and wound dehiscence. Data was analysed statistically using Chi-square test.

Results: Time required for study group was significantly lesser than control and the length of suture required was also significantly less. Wound infection rate in study group was lesser than control but the difference was statistically insignificant ($p > 0.05$). Wound dehiscence rate was significantly less in the study group ($p < 0.05$) compared to control group.

Conclusions: In Smead-Jones method of closure tension between two loops is distributed in such a way that the fascial edges are well approximated. Originally described method was interrupted. Continuous method has advantage of being faster and has less risk of wound dehiscence due to dynamic distribution of increased tension in postoperative period due to see-saw effect. We proposed modification of original Smead-Jones technique by doing it in continuous manner to increase the benefits and found this method to be fast, cost-effective, equally effective in controlling wound infection and better than interrupted technique to prevent wound dehiscence.

Keywords: Contaminated surgeries, Continuous, Interrupted, Midline laparotomy fascial closure, Smead Jones method, Wound dehiscence

INTRODUCTION

A midline incision is the most commonly used access route for emergency laparotomy as it is simple, quick, bloodless, has best extensibility and provides excellent exposure.^{1,2} But its drawbacks are comparatively increased incidence of postoperative wound dehiscence and an incisional hernia compared to other incisions.³ Many factors influence wound complications like wound

sepsis and dehiscence. Some of the patient related factors are their nutritional status, hypoalbuminaemia, anaemia, immunosuppressed states, renal failure, uncontrolled diabetes, malignancies, steroid therapy and obesity. Other set of factors which influence the strength of repair and healing are related to the technique of suturing. Some of them are the size and type of suture material used (monofilament versus polyfilament, absorbable vs. non-absorbable, natural versus synthetic) and also the

technique of suturing layered versus mass closure, interrupted and continuous.^{4,5}

Majority of the studies suggest that, the most effective method of midline abdominal fascial closure in the elective setting is mass closure incorporating all layers of abdominal wall except skin in continuous technique with No. 1 or 2 delayed absorbable monofilament suture material with suture length to wound length ratio 4:1.⁴⁻⁷ A recent meta-analysis by Gupta H et al of 23 randomised controlled trials showed that odds of the burst are reduced to half with the interrupted method of closure as compared to continuous.⁸ Thus debate continues about the best method of midline abdominal wall closure in emergency, contaminated cases and no consensus exists about this issue.

As a result of these controversies, practices of midline laparotomy wound closure are highly influenced by surgeons' personal preferences, individual experience, and tradition of institute.^{4,9} There is no controversy about mass closure technique being superior to layered closure for midline laparotomy fascial closure in preventing wound dehiscence and incisional hernia.^{10,11} Thus we designed a study to find out the efficacy of two different types of mass closure techniques namely interrupted and modified continuous Smead-Jones technique to address the controversy.

METHODS

This is a prospective nonrandomised interventional case-control study carried out in the general surgery department of a tertiary care teaching hospital after ethical clearance for the period of 20 months wherein all patients requiring emergency midline laparotomy between the age group of 18 to 70 years were included whose surgeries could be classified as contaminated or infected/dirty. Patients were enrolled after obtaining their informed written consent. Patients who qualified to be enrolled had pathologies like a perforated duodenal ulcer, small bowel and colonic perforations, traumatic bowel perforations, generalised peritonitis due to appendicular perforation or ruptured liver abscess, pancreatic abscess/necrosis, diverticular abscess, ruptured empyema gallbladder etc. and they required emergency laparotomy through midline incision. Presence or suspicion of the abdominal compartment syndrome was excluded. Patients having previous midline laparotomy scars were excluded. Children and pregnant women were also excluded.

Those patients who did not survive till 30 days period postoperatively were dropped out of the study. Patients requiring 2nd surgery through the same incision within the period of initial 30 postoperative days were also dropped out. And patients who had adverse factors wound healing like uncontrolled diabetes mellitus, severe malnutrition, immunosuppressed states, post radiation and steroid therapy were excluded.

All eligible patients were allocated to either study or control groups alternately till 50 patients in each group after subtraction of dropped out patients. Study group underwent midline laparotomy closure by our modification of Smead-Jones technique in continuous fashion and control group underwent midline fascial closure by interrupted sutures. In both the groups no. 1 monofilament delayed absorbable (polydioxanone) was used to suture the fascia. In both groups, fascial closures were carried out by qualified junior consultants or senior registrars under direct consultant supervision. Other infection control measures like preoperative surgical site preparation, aseptic techniques and antibiotic prophylaxis used were similar in both the groups. The time required and the length of suture material required in comparison to the length of laparotomy wound was measured and recorded in predesigned case record sheets.

Originally described Smead-Jones closure technique of far-near and near-far suturing was interrupted. But we proposed continuous far-near and near-far suturing technique as modified Smead-Jones technique, which was used for midline fascial closure in the study group. In this technique suturing was done as shown in the figure 1, with points 'A' and 'D' being 1.5 cm away from the edge of the fascia and points 'B' and 'C' being 0.5 cm away from the fascial edge. The distance between two successive continuous sutures was not more than 1 cm. There was one 2 x 1 x 1 x 1 surgical knot at each end of laparotomy wound.

In the controlled arm, midline closure was done with interrupted sutures 1.5 cm away from the cut margin/edge of fascia tied every time with 2 x 1 x 1 x 1 surgical square knots. Again distance between two consecutive sutures was not more than 1 cm.

All patients underwent preoperative requisite investigations and optimization of physiological abnormalities as per standard protocol. All patients were operated under either general anaesthesia or general + epidural anaesthesia. Necessary surgical procedures were carried out as per the pathologies encountered. All patients were followed up till 30 days postoperatively for 2 outcome parameters namely, wound infection and wound dehiscence.

Wound infection was defined as the presence of seropurulent discharge through the sutured wound or erythema / induration around suture line for more than 2 cms on either side necessitating removal of skin sutures for drainage of infected fluid or pus and lavage of the wound as assessed by consultant surgeon. Wound dehiscence was defined as the separation of the two edges of the laparotomy fascia with visible bowel, omentum, mesentery or other intraperitoneal structures through it with or without fibrin layer cover. Wound burst occurring within 1st postoperative week which required surgical intervention for repositioning of eviscerated contents was also included in wound dehiscence.

All data were entered in predesigned case record forms and statistical analysis was done using Chi-Square test considering $p < 0.05$ as statistically significant.

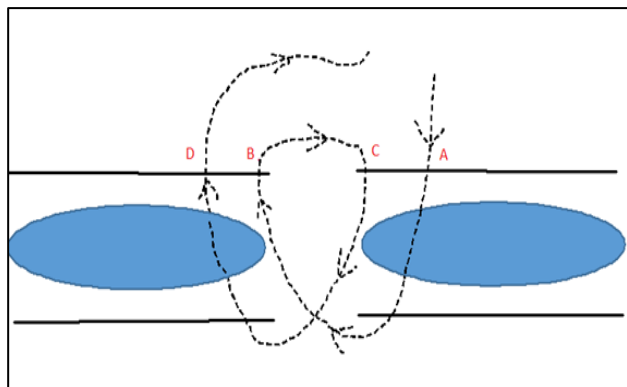


Figure 1: Smead-jones technique.

RESULTS

Mean age in the control group was 38 years (range 25 - 70 years) and that in the study group was 41 years (range 28-68 years). M:F sex ratio was 6.8:3.2 in the control group and that in the study group was 7:3.

The commonest pathology encountered during laparotomies overall was duodenal ulcer perforation(36%), followed by typhoid ileal perforation(19%), tuberculous ileal perforation (17%), traumatic small intestinal perforation(14%), colonic perforation (7%) and appendicular perforations causing generalised peritonitis (6%) in that order (Table1). Relative distribution of all these pathologies in each of the groups also followed almost similar proportion patterns.

Table 1: Depicts distribution of pathologies which qualified as contaminated surgeries.

Pathologies	Control group (interrupted mass closure) n = 50	Study group (continuous smead-jones) n = 50	Total
Duodenal ulcer perforation	16 (32%)	20 (40%)	36
Typhoid ileal perforation	11 (22%)	08 (16%)	19
Tubercular ileal perforation	08 (16%)	09 (18%)	17
Traumatic small bowel perforation	06 (12%)	08 (16%)	14
Colonic perforation	04 (8%)	03 (6%)	7
Appendicular perforation with generalised contamination	05 (10%)	02 (4%)	06
Total	50 (100%)	50 (100%)	100

Table 2: Comparison of time required for closure, length of suture required and technique.

	Control group	Study group	p- value
Mean time required for each 10 cm closure	6.4 minutes	4.8 minutes	<0.05
Mean length of suture required for 10 cm of closure	78 cms	56 cms	<0.05

Table 3: Correlation of wound infection and closure method.

Technique	No. of wound infection (n = 50)	Percentage
Control (interrupted closure)	19	38
Study (continuous smead-jones)	16	32

p-value insignificant (>0.05).

In analysis of time taken for closure it was found in the control group mean time required for each 10 centimetres of incision was 6.4 minutes (range 5 to 8 minutes) whereas mean time required for study group for the same distance was 4.8 minutes (4 to 6 minutes) which was less than control and the difference was statistically significant (Table 2).

Table 4: Correlation between wound dehiscence and closure method.

Technique	No. of wound dehiscence (n=50)	Percentage
Control (interrupted closure)	12	24
Study group (mod. continuous smead-jones)	4	8

p-value < 0.05 (significant).

The mean length of the suture required for each 10 centimetres of the incision was 78 centimetres in the control group whereas that in the study group was 56 centimetres. This difference in suture requirement was

statistically significant ($p < 0.05$). Thus continuous smead-jones method of closure was more cost effective.

In control group that is those who underwent interrupted fascial closure rate of wound infection was 38% ($n = 19/50$) whereas in study group that in those who underwent midline fascial closure by modified continuous Smead-Jones method wound infection rate was 32% ($n = 16/50$) (Table 2). Thus it was lesser in the

study group but the difference was not significant statistically ($p > 0.05$).

Rate of wound dehiscence was much lesser in study group (8%) compared to control (24%). This difference was statistically significant ($p < 0.05$) suggesting that study method is superior to control in preventing postoperative wound dehiscence (Table3).

Table 5: Occurrence of outcome parameters as per etiology.

Etiology	Control group (interrupted mass closure)		Study group (continuous smead-jones)	
	Wound infection	Wound dehiscence	Wound infection	Wound dehiscence
Duodenal ulcer perforation	7/16 (43.73%)	3/16 (18.75%)	6/20 (30%)	1/20 (5%)
Typhoid ulcer perforation	3/11 (27.27%)	2/11 (18.18%)	3/8 (37.5%)	1/8 (12.5%)
Tubercular ileal perforation	3/8 (37.5%)	3/8 (37.5%)	3/9 (33.33%)	1/9 (11.11%)
Traumatic small bowel perforation	2/6 (33.33%)	1/6 (16.66%)	3/8 (37.5%)	0/8 (0%)
Colonic perforation	2/4 (50%)	2/4 (50%)	1/3 (33.33%)	1/3 (33.33%)
Appendicular perforation with generalised contamination	2/5 (40%)	1/5 (20%)	0/2 (0%)	0/2 (0%)
Total	19/50 (38%)	12/50 (24%)	16/50 (32%)	4/50 (8%)

In control group that is interrupted closure, overall wound infection rate was 38%. Among this group it was maximum in colonic perforations (50%) followed by 43.73% in duodenal ulcer perforation and was 40% in patients with appendicular perforations. Wound infection rate was less than average for the control group in tuberculous (37.5%), traumatic (33.33%) and typhoid (27.27%) perforations. Average wound infection rate in study group was found to be 32%. Differential rate of wound infection in Study group was between 30 to 37% for all other pathologies except appendicular perforation for which it was zero (Table 5).

Overall wound dehiscence rate in control group was 24% and that in study group was 8%. No patient with appendicular perforation had wound dehiscence in study group as compared to 20% in control group. Wound dehiscence rate for duodenal ulcer perforation was 18.75% and 5% for control and study group respectively.

Similarly dehiscence rates was control and study groups for typhoid perforations were 18.18% and 12.5%; that for tuberculous perforation was 37.5% and 11.11%, for traumatic perforations was 16.66% and 0% and that for colonic perforations was 50% and 33.33% respectively (Table 5).

DISCUSSION

Wound healing progresses through three phases namely phase of inflammation then proliferation and last

maturation or remodelling. Fascia is slow to heal and regains up to 60% of tensile strength by 45 days up to 75% by 120 days and 80% by 180 days. Maximum tensile strength regained is never more than 90%.^{12,13}

The purpose of any suturing technique is to provide enough support to the healing wound without undue stress on the wound till adequate tensile strength is regained by healing tissues. Any suturing technique should be fast, simple, easy to perform, give enough support to healing tissue till it regains at least half of its original tensile strength. It should do so without causing compromising to blood supply of tissues, without predisposing to the development of infection, should be tension free and should preserve compliance of the abdominal wall. It should also be patient friendly and causes the least discomfort to patients in the postoperative period.

Clinically important complications of the midline laparotomy wound closure after contaminated emergency surgeries in early postoperative period are wound sepsis/infection and dehiscence/burst abdomen. Some of the other less bothersome being suture sinus formations which appear late. One of the major mechanisms of wound dehiscence is suture cutting through linea alba which is responsible for the majority of cases of dehiscence; other less likely mechanisms being suture breaking or knot undoing due to postoperative stress/tension over the suture repair.

Most of the studies recommend the use of continuous mass closure of linea alba rather than interrupted technique. The reason being continuous suturing is faster and have an even distribution of tension over entire suture line due to see-saw or hacksaw effect.¹⁴ When abdomen distends in postoperative period loops of continuous sutures readjust in such a way (due to inherent elasticity) that tension gets evenly distributed along suture line by see-saw like to and fro movement of loops of suture over the abdominal wall and compliance of abdominal wall is preserved.^{1,15}

According to study by Jenkin, in postoperative period, midline laparotomy wound length can increase up to 3 times due to abdominal distension and factors like violent coughing, retching, bowel oedema, ileus, third space fluid entrapment etc. Hence Jenkin recommended to maintain suture length to wound length ratio of 4:1 for continuous repairs.^{4,7} If bites taken by a surgeon and associated suture length is not large enough to accommodate the potential increase in wound length than the suture is likely to cut through the fascia resulting in dehiscence. Jenkin by the use of geometrical principles and rules applying to the component sides of triangle concluded the above ratio to avoid suture tearing through fascia during increased dynamic stress due to the expansion of wound length.

In contrast to continuous technique, interrupted suture loop gets unevenly exposed to deleterious effects of excessive tension which makes it prone to cut through the linea alba. Dynamic distribution of increased tension as discussed above cannot operate. Whipple and Elliot¹⁶ indicated that tying suture too tight in interrupted cause strangulation and ischaemic necrosis of tissue between the loop, which results in significantly lower wound strength than when edges are just approximated.¹⁷⁻¹⁹ Other disadvantage of the interrupted suturing technique is increased number of knots causing more pain and discomfort and increased incidence of sinus formation late in the postoperative period.

Previous studies suggest that strength of repair also depends on the thickness or diameter of suture strand. For midline laparotomy fascial closure suture size of No. 1 or 0 is appropriate. And the smallest amongst the required size of suture thickness is advised to be used which minimises the amount of suture mass in the tissues.⁴ Double-stranded loop suture material appears to give better strength but it needs to be studied further for approval and sometimes it is associated with increased pulmonary complications due to decreased compliance of abdominal wall musculature and thus may not be necessary, moreover it increases the suture mass in healing tissues and knots are too bulky.¹⁴

Smead in 1900 proposed method of interrupted double loop fascial closure and it was popularised later by Jones in 1941. This technique causes more secure approximation of fascial edges without losing much

elasticity or compliance. Increased tension between two loops in Smead-Jones technique is distributed in such a way that wound edges remain well approximated without sutures cutting through.²⁰

We modified original Smead-Jones technique of interrupted closure to continuous Smead-Jones technique to overcome the disadvantages of interrupted suturing, gaining the benefit of continuous closure technique and simultaneously preserving advantages of originally described Smead-Jones technique.

In our study we found wound infection as one of the main complication of fascial closure, occurring in 38% of patients in controls and 32% in study group (Table 3), which was higher than 29.6% of wound infection in study by Elkheir et al in 2014 but comparable to 33.33% wound infection rate in the study by Murtaza B et al.^{14,1} In our study wound infection appears to be less frequent in the study group compared to control but the difference could not achieve statistical significance. Hence we concluded that in comparison to interrupted technique, modified continuous Smead-Jones technique of fascial closure is equally effective in controlling postoperative wound infection.

Burst abdomen is the complete wound dehiscence which typically occurs in the early postoperative period between 6th to the 8th day when there is evisceration of contents of peritoneal sac.^{21,22} Badar M et al reported wound dehiscence rate of 2.77% in high-risk laparotomies.¹ Rehman A et al reported wound dehiscence rate of 13.75% and 2.5% for continuous and interrupted closure respectively.²³ Various authors have reported laparotomy wound dehiscence rates ranging from 5-30% in emergency cases.^{6,9,24,25} In our study, we found wound dehiscence rate of 24% in the interrupted group which was higher than 8% dehiscence rate in modified continuous Smead-Jones technique (Table 4) and the difference was statistically significant ($p < 0.05$), thus proving the later method superior to the former in preventing postoperative wound dehiscence. We did not study the effect of both methods on late complications viz. development of an incisional hernia, but the rate of development of an incisional hernia appears to be proportional to wound dehiscence rate.

Our study method was cost-effective as it required lesser length of suture material (Table 1) due to continuous suturing and was more patient friendly as it resulted in lesser postoperative pain due to reduced incidence of sutures sinus formation due to lesser number of knots compared to interrupted technique. Our modified technique could be performed or completed in significantly less time compared to the interrupted method (Table 2) and according to Cruze PJ et al time for surgery was a significant determinant of incidence of surgical site infection.²⁶ Thus we conclude that modified continuous Smead-Jones technique is faster, cost effective, patient friendly method of midline laparotomy

fascial closure for emergency contaminated cases which is equally effective to interrupted technique in preventing wound infection and more effective than interrupted technique in preventing postoperative wound dehiscence. Hence it can be recommended for the above purpose.

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Ethical approval: The study was approved by the institutional ethics committee

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