

## Comparison of Continuous Versus Interrupted X Suture Technique To Prevent Wound Dehiscence After Midline Laparotomy- A Prospective Study

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### Abstract:

**Introduction:** Midline vertical mass closure technique remains a procedure under constant debate that often reflects a surgeon's personal preference and rely mostly on traditional previous experiences.<sup>1</sup> Midline laparotomy incision for emergency or elective surgery allows quick, simple and satisfactory exposure to all quadrants with minimal blood loss.<sup>2</sup> Wound hematoma, surgical site infection, gaping, wound dehiscence, evisceration, incisional hernia, sinus formation and hypertrophic scar are some of the common post-operative complications. Apart from patient's factor, suture material and method of closure are main factors related to these complications. This study compares the continuous sutures and interrupted x-type sutures in mass closure of midline laparotomy wound in Indian setup.

**Materials and method:** Comparative prospective hospital based study was conducted in a tertiary health centre of northern India for 12 months after ethical approval and obtaining informed written consent. In control group continuous closure was performed and in study group Interrupted X suture closure was done to close the midline laparotomy incision. Early complications were noted and after discharge patients were followed up at 15 days, 3 months, 6 months and 1 year interval. Data was collected in a pre-structured pre-tested Performa. Analysis was done using Epi-Info version 7.2.3.1.

**Results:** Total 200 patients participated in the study. Contamination of incision site was not statistically significant in both the groups. The hospital stay of almost 5-10 days was also similar in both groups. The surgical site infection was present in 85 (42.5%) patients. Out of 85, 38 (44.7%) patients developed wound dehiscence in post-operative period. Thus surgical site infection was a highly significant predictor of wound dehiscence (p value = 0.00001) Occurrence of wound dehiscence and evisceration was significantly higher in continuous suture group as compared to interrupted X suture group.

**Conclusion:** Interrupted X suture prevented the occurrence of wound dehiscence and evisceration significantly as compared to continuous suture in our study. A larger randomized control trial with a longer follow-up period is needed for evaluating long term complications like sinus formation and incisional hernia in both groups.

**Key Words:** Continuous suture; X-interrupted suture; Wound dehiscence; incisional hernia.

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### I. Introduction

Laparotomy wound dehiscence is a term used to describe separation of the layers of a wound before complete healing. It is also used interchangeably as 'acute laparotomy wound failure' or 'burst abdomen' or gravely as 'evisceration' and 'eventration'. Wound dehiscence can be occult or overt, partial or complete. Historically, wound dehiscence up to 10% is reported with contemporary series estimating an incidence between 1 and 3%<sup>3,4</sup> and mean time for wound dehiscence at 8-10 days after operation.<sup>5,6</sup> There is a continuing research and debate about the best method of closure of midline vertical abdominal wound following an emergency laparotomy as no institute could achieve 0% failure rate despite best efforts.<sup>7</sup> The debate gains importance in Indian setup as burst abdomen is associated with high morbidity and mortality (10-30%)<sup>5</sup> along

with considerable increase in the cost of care both in the form of increased hospital stay and manpower required in managing wound dehiscence and its complications.

Wound dehiscence is related to several factors pertaining to patient besides suture material and method of closure.<sup>8</sup> Since the dawn of history of surgery, many different variety of suture materials and techniques have been tried and advocated at different times, but no suture material and technique has given a total satisfactory result as far as closure of vertical abdominal incision is concerned.<sup>9,10,11</sup> Technical errors like poorly placed incision, wrong suture selection and unsatisfactory closure technique have lead to post-operative complications like wound hematoma, surgical site infection, gaping, wound dehiscence, evisceration, incisional hernia and hypertrophic scar.

Midline laparotomy is the commonest technique of abdominal incisions in both emergency and elective settings because it is simple, provides adequate exposure to all four quadrants, affords quick exposure with minimal blood loss.<sup>2</sup> Minimization of tissue damage is essential, and this may be done by avoiding inclusion of the abdominal wall musculature in the closure. A 4:1 ratio of suture bites versus suture advancement has been advocated.<sup>12</sup> Mass closure of abdominal wall is preferred over layered closure.<sup>13</sup> The current opinion in the most of Western countries is of running mass closure of the abdominal wall in both emergency and elective setting as patients are nutritionally well built and they present earlier to the hospital. The use of continuous suture has been advocated to prevent early wound dehiscence and late wound hernia. The concept of this technique is supported by theoretical consideration and clinical experience.<sup>11</sup> However, in developing countries such as India, many patients turning to government hospitals have a poor nutritional status and have delayed presentation with sepsis, thus making the problem of wound dehiscence even more common and grave. This problem also gets compounded with high prevalence of co-morbid disease like tuberculosis and typhoid which are detrimental to healing.<sup>14</sup> In this scenario interrupted suturing has been found to give good strength and have less incidence of wound dehiscence.<sup>15</sup> Hence, it is imperative for us to ascertain and advocate the safest method of closing the abdomen in Indian scenario. This study tries to evaluate prospectively the continuous sutures compared with interrupted x-type sutures in mass closure of midline laparotomy wound using No. 1 PDS (polydioxanone, slowly absorbing monofilament suture) and its effectiveness in various co-morbidities.

## II. Materials And Methods

Comparative prospective hospital based study was conducted in a tertiary health centre of North India for 12 months after ethical approval. A total of 200 patients undergoing midline laparotomy for acute or elective abdominal conditions, namely, intestinal obstruction, peritonitis, abdominal trauma and malignancy were recruited randomly (through the chit box method) after taking written informed consent and were equally divided into 2 groups of 100 patients each, control group (continuous suture) and study group (interrupted X suture). Patients younger than 18 years of age or older than 75 yrs, having a previous laparotomy or burst abdomen or incisional hernia at presentation, with immuno-compromised state, on chemotherapy/immunotherapy or long term steroids were excluded. Early complications (Cough, discharge, abdominal distension, wound gaping, dehiscence and anemia) were noted at 7<sup>th</sup> & 14<sup>th</sup> day and after discharge patients were followed up at 3 months, 6 months and 1 year interval. Data was collected in a pre-structured pre-tested Performa. Analysis was done using Epi-Info version 7.2.3.1.

### *Suturing Techniques*

**Continuous Closure :-** It was performed using No. 1 PDS suture (polydioxanone , Johnson & Johnson Ltd., India), care being taken to place each bite 1.5–2 cm from the cut edge of linea alba and successive bites being taken 1 cm from each other. The edges of linea alba were gently approximated without strangulation with an attempt to keep a suture towound length ratio of 4:1 (Fig-1)

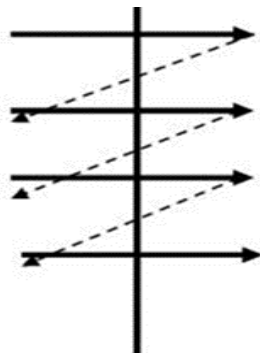


Figure – 1

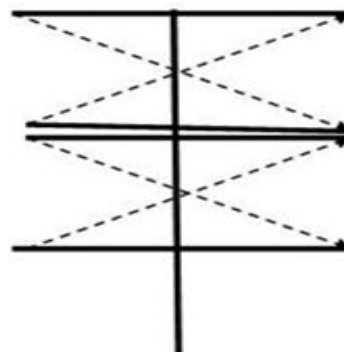


Figure - 2

**Interrupted Double-X Closure:-** It was performed using No. 1 PDS suture (polydioxanone , Johnson & Johnson Ltd., India). A large bite was taken on the cut edge of linea alba from outside-in, 2 cm from edge. The needle emerged on the other side from inside-out diagonally 2 cm from the edge and 4 cm above or below the first bite. This strand was crossed or looped around the free end of suture and continued outside-in, diagonally at 90° to the first diagonal. The two ends were tied just tight enough to approximate the edges of linea alba taking care not to include bowel or greater omentum between the edges. The small free end of the suture was passed deep to the X behind linea alba and again tied to the other end of the suture. This method of tying four throws in front and four throws behind the X created two X-like crosses—one on the surface and another deep to linea alba. The central knot allowed fixation of four arms of the X like a pivot. The next X-suture was placed 1 cm away (above or below) from the previous one. Thus, in a 14 cm long wound, 3 X-sutures were applied (Fig.2). The suture line was then palpated for any gap with the index finger. Any large gap permitting a finger was closed with a simple interrupted suture.

### III. Results

The main outcome variable was presence of an abdominal wound dehiscence or burst. This was recorded as a binary variable—present/absent. A burst was considered present when intestine, omentum, or other viscera were seen in the abdominal wound up to 30 days from the date of operation.

The following predictor variables were also recorded and coded as a binary variable -present/absent (with cut off values):- Intra-peritoneal sepsis, Total Leucocyte Count (>10000/mm<sup>3</sup>), Cough, Diabetes (FBS>140 mg/dl or RBS>200 mg/dl), Abdominal distension, Serosanguinous discharge, Wound gaping, Wound Dehiscence, Malnutrition (weight <70 % of expected weight or serum albumin <3.5 g/dl), Anemia (<10 g/dl), Uremia (blood urea > 50 mg/dl), Type of Procedure (Emergency/Elective) and Method of suturing (coded as 0 for continuous; 1 for interrupted X method).

#### *Statistical Analysis*

Quantitative data was presented as mean and range as appropriate. For normally distributed data, mean was compared using T-test. For discrete categorical data, number and percentage were calculated. Chi-Square tests or Fisher's exact tests were applied for categorical data. All statistical tests were two sided. A p value of <0.05 was considered to indicate statistical significance. Analysis was conducted using Epi-Info version 7.2.3.1.

**Risk of burst:** The risk (cumulative incidence) of burst was calculated as the number of burst abdomen patients in a group/total number of patients in that group.

**Relative risk of burst abdomen:** The relative risk of the interrupted group as the “exposure” was calculated against the continuous method as the “reference” category. The data from both the above study was collated. The combined results are presented below.

#### *Age Distribution-*

In present study the mean age of patients was 47.08 years (S.D.±15.81) in conventional continuous closure group and 45.65 years (S.D.±14.93) in interrupted X-suture closure group. Both age groups were comparable and did not show any significant difference (p=0.51)

#### *Gender Distribution-*

In this study there were 79% males and 21% females in Group 1 while there were 89% males and 11% females in Group 2. Both Groups were comparable with respect to the sex distribution of the patients (p = 0.0537). Overall there were 168 (84 %) males and 32 (16 %) females enrolled in the study.

#### *Method of Suturing-*

38 (19 %) out of 200 patients developed burst in the post-operative period. In Group 1, 32 patients developed wound dehiscence and in Group 2, there were 6 patients with wound dehiscence. The difference of wound dehiscence in two groups was statistically significant on Chi-Square test with a p value of <0.00001.

#### *Risk of Burst-*

Stratified analysis was performed for the significant predictors to better understand the efficacy of the two methods under different conditions.

Relative risk (RR) for burst abdomen with continuous method as “reference” category and interrupted method as “exposure” category was 0.1875 (P00.0003). The prevented fraction was 81.25 % (Table 1&2).

This prevented fraction indicates that 81% of bursts were prevented by application of interrupted suture that would have occurred if abdomen was sutured with a continuous suture.

### ***Intraperitoneal Sepsis and Burst Abdomen***

Patients having septicemia have relatively poor wound healing. Intraperitoneal sepsis was present in 77 (38.5 %) cases. 23 (17 %) of these developed burst abdomen. On the other hand, out of the remaining 123(61.5 %) cases where no contamination of the peritoneal cavity was observed, only 15 (12.19 %) of these developed burst. RRsepsis for burst =2.44 (P00.0005).

### ***Hypoalbuminemia and Burst Abdomen***

Adequate nutrition is essential to support cellular activity, timely recovery and wound healing. In Group 1, 37.33% (28) of patients who were having hypoalbuminemia developed wound dehiscence (p value=0.047) and in Group 2, 8.96% (6) patients who were having hypoalbuminemia developed wound dehiscence (p value=0.083). Overall 142 patients had hypoalbuminemia out of which 34 (23.9%) developed wound dehiscence. On the other hand, out of the remaining 58 cases where no hypoalbuminemia was observed, only 4(6.89%) cases developed burst. RRhypoalbuminemia for burst =3.46 (P00.0005). On statistical analysis, it is found that poor nutrition in form of hypoalbuminemia is significant risk factor in wound dehiscence.

### ***Cough and Burst Abdomen***

COPD and postoperative pulmonary complications are important factor that may increase intra abdominal pressure in post operative period through coughing, which may delay wound healing and may lead to wound dehiscence. In current study of 200 cases, 101 (50.50%) presented with cough or developed cough in early post-operative period. Out of 101, 43.55% (27) patients in Group 1 and 10.26% (4) patients in Group 2, had cough and developed wound dehiscence. On analysis, Chi-Square Test, it showed that variation between the two groups was statistically significant with a p value of 0.000413. Collectively, out of 101 cases who presented with cough preoperatively, 31 (30.7 %) went on to develop burst abdomen. Of those, not having preoperative cough (99 cases), 7(7.0 %) developed burst (RRcough =4.39). Evidence of chest infection was present in all these cases clinically as well as radiologically.

### ***Diabetes and Burst Abdomen***

Diabetes is a systemic disease and causes immunosuppression with delayed wound healing. In present study, 13 out of 200 patients were diabetic. Out of 13 diabetic patients, 7 patients were in Group 1 and 6 patients were in Group 2. Out of 187 patients who were not diabetic, 38 developed burst abdomen. Although there is correlation between wound infection and wound dehiscence associated with diabetes mellitus but, in this study, patients had good glycemic control and none in both groups having diabetes mellitus developed wound dehiscence. On statistical analysis the fisher exact test the p value was 0.683 which was not significant.

### ***Uremia and Burst Abdomen***

Out of 200 patients, 39 patients were having uremia, with 20 patients in continuous group and 19 patients in interrupted X suture group. 7 (35%) out of the 20 patients in group 1 and 2 (10.53%) out of 19 patients in group 2 developed wound dehiscence. Collectively Burst abdomen with uremia was seen in 9 (23.07 %) cases. RRuremia =1.27 (P00.000). Thus presence of uremia was a highly significant factor in predicting wound dehiscence.

### ***Anemia***

Low hemoglobin causes poor oxygen supply to tissue and therefore poor tissue healing and inability to resist infection. In Group 1, 50% (10) of patients who were anemic developed wound dehiscence (p value = 0.053) and in Group 2, 15.38% (2) patients who were anemic developed wound dehiscence (p value = 0.173). Burst occurred in 12 (36.36 %) of 33 patients with anemia. However, twenty six (15.56 %) of 167 patients without anemia also had burst abdomen. On statistical analysis, Chi-Square test, it showed that variation between two groups was insignificant. Thus, anemia was not a detrimental factor (RRanemia =2.4); reinforcing the results obtained in various previous studies<sup>16,17,18</sup>.

### ***Surgical Site Infection and Burst Abdomen***

Wound infection (SSI) and wound gaping is very common after laparotomy. In the present study of 200 patients, the surgical site infection and wound gaping was present in 85 (42.5%) patients and 38 (44.7%) of these patients eventually developed wound dehiscence after prior infection. Of those not having surgical site infection, not a single patient developed burst abdomen postoperatively. Thus surgical site infection was a highly significant predictor of wound dehiscence (p = 0.00001).

**Abdomen distension and wound dehiscence**

In our study, abdomen distension was present in 30 (15%) patients. Out of 30 patients who developed abdominal distension, 12 (40%) patient had abdominal wound dehiscence in post-operative period. Out of 170 patients not having abdominal distension, only 26 (15.29%) patients developed wound dehiscence. On statistical analysis the p value on Chi-Square was 0.001. Thus abdominal distension was a highly significant predictor of wound dehiscence (RRdistension = 2.63).

**Type of Surgery and Burst Abdomen**

Inquest was made into the risk of burst abdomen among the elective and emergency surgical procedures using different suturing techniques. In the current study, 184 (92%) patients were operated in emergency while 16 (8%) patients were operated in elective setting.

*Emergency Operations-* Of 184 emergency surgeries, 32 (17.39 %) patients developed burst. The risk of burst in continuous arm was 28.89 % (26/90) as opposed to 6.38 % (6/94) in interrupted X arm (p value=0.010).

*Elective Operations-* The risk of burst in continuous arm was 60 % (6/10). No bursts were reported in interrupted X arm (p value=0.121).

There was statistically significant wound dehiscence in emergency procedure group. Hence, it was observed that interrupted X suture techniques can preferably be used in all emergency or elective laparotomy cases presenting with one or more risk factors for burst abdomen.

**Table 1 Comparison of baseline characteristics among the two groups**

Characteristic	Continuous method N=100	Interrupted-X suture N=100
Age (std. deviation)	47.08 (15.81)	45.65 (14.93)
Gender (male/female)	79/21	89/11
Emergency/elective surgery (Burst)	90/10(26/6)	94/06(6/0)
Hypoalbuminemia (Burst %)	28 (37.33)	06 (8.96)
Distension (Burst %)	10 (83.33)	02 (16.66)
Intra-peritoneal sepsis (Burst %)	19 (46.34)	04 (11.11)
Cough (Burst %)	27 (43.55)	04 (10.26)
Diabetes (Burst %)	0/7 (0)	0/6 (0)
Anemia (Burst %)	10 (50)	02 (15.38)
Uremia (Burst %)	07 (35)	02 (10.53)

**Table 2 Showing relationship between methods of suturing and burst abdomen**

Burst abdomen	Method of suturing n (%)		Total
	Continuous	Interrupted-X	
Yes	32	06	38
No	68	94	162
<b>Total</b>	<b>100</b>	<b>100</b>	<b>200</b>
<b>Risk of burst</b>	<b>0.32</b>	<b>0.06</b>	<b>0.19</b>

Relative risk of burst, Point estimate = 0.1875, 95 % C.I.: 0.13 to 0.58

Prevented fraction for burst, Point estimate = 81.25 %, 95 %C.I - 41.59 % to 86.52 %

**IV. Discussion**

“I dressed the wound and God healed them” is the famous saying of Ambrose Parre (1510-1590). It is every surgeon’s desire that after suturing the wound, it should heal without any complications. Wound closure aims at minimizing risk of wound infection, dehiscence, incision hernia, sinus formation and adhesion of intestines to the abdominal wall with subsequent obstruction. The procedure should be quick and easy with low incidence of post-operative wound pain and respiratory complications and should not interfere with stomas. In general primary closure of wound should achieve careful apposition of wound edge, avoidance of strangulation of tissues, give mechanical support to the wound and hold wound margins together until sufficient healing has taken place. The specific technique used in closure of the abdominal fascia for the individual is frequently based on non-scientific factors. Because of difficulties arising from differently tailored study designs, the surgical literature has not clearly demonstrated an optimal technique to close abdominal fascia, especially in emergency settings.

Theoretically two factors may be concerned in the causation of burst abdomen, either the intra abdominal pressure is too great or the wound is too weak. However the intra abdominal pressure is frequently not within surgeons control but wound must be made sufficiently strong to withstand this pressure. During the



postoperative period a wound must depend for its strength on cohesion of the healing tissue, bandage or dressing and type of Suture used.

The mean age of patients taken for study was 47.08 years (S.D  $\pm$ 15.81) in conventional continuous closure group and 45.65 years (S.D  $\pm$ 14.93) in interrupted X-suture closure group, did not show any significant difference ( $p=0.51$ ) between the two groups and both age groups were comparable. Mean age in both the group was found out to be similar to another recent study done in India.<sup>19</sup> Male predominance similar to our study has been observed in majority of the studies in past.<sup>20,21</sup> Most common diagnosis in both groups was peptic perforation (28% in group 1 and 32% in group 2) followed by illeal perforation. The surgical site infection was present in 85 (42.5%) patients. Out of 85, 38 (44.7%) patients developed wound dehiscence in post-operative period. Thus surgical site infection was a highly significant predictor of wound dehiscence ( $p$  value = 0.00001). In this study, 184 (92%) patients were operated in emergency and 16 (8%) operated in elective setting. 38 (19%) developed wound dehiscence, 32 (84.21%) developed wound dehiscence in emergency procedure and 6 (15.78%) patients developed wound dehiscence in elective procedure. Similarly, higher incidence of infection was also present in a study by Gislason et al which also included high proportion of emergency operations (32%).<sup>22</sup> Cruse and Foord found in a retrospective survey a wound infection rate of 40% among 2,093 dirty wounds but they did not specify how skin closure was performed.<sup>23</sup> The wound infection was not found to be statistically affected by the technique employed. Use of non-absorbable sutures for abdominal closure (e.g., polypropylene) has been associated with increased pain and sinus track formation and has not shown any significant difference in the incidence of incisional hernia formation, wound dehiscence, or surgical site infection as compared with slowly absorbing monofilament suture, such as polydioxanone.<sup>24,25</sup> There is lack of data about the persistence of wound infection while comparing the above two techniques and sutures. Wound infection rate was found to be considerably higher than in other studies because our study included patients undergoing clean- contaminated or contaminated surgeries.

In our study there were 32 cases of burst abdomen out of total 100 in continuous group (group 1) and only 6 burst abdomen out of total 100 subjects in interrupted group (group 2). There was statistically significant difference in occurrence of wound dehiscence in favour of interrupted suture technique (Relative risk RR = 0.1875) same as in the study done by Chandra Shekhar Agrawal et al (2012) where RR for burst abdomen with continuous method as “reference” category and interrupted method as “exposure” category was 0.280 (95 % CI 0.135–0.584;  $P = 0.0003$ ).<sup>26</sup> Our study thus shows that interrupted suture technique is better than continuous suture in preventing burst abdomen. Total 38 patients (19 %) suffered from wound dehiscence; this higher rate of burst abdomen in our study can be primarily be explained by the fact that our study included majority of the patients undergoing emergency surgery for peritonitis (184/200), which constitutes a major source of sepsis. Richards et. al. also concluded that statistically significant difference in incidence of burst abdomen is present in infected wounds than in non-infected wounds ( $p<0.02$ ).<sup>21</sup> Maximum wound dehiscence occurred at 5<sup>th</sup> to 7<sup>th</sup> post operative day in both the groups. Further management of this complication required regular aseptic dressing and secondary suturing. The mean duration of hospital stay was significantly lower in group 2 (interrupted group) compared to group 1 (continuous group) due to less early complications in group 2 patients.

Intraperitoneal sepsis, cough, uremia and wound infection were other significant predictors of burst abdomen in our study as earlier studied by Chandra Shekhar Agrawal et al.<sup>26</sup> The occurrence of burst increases risk of chest infection due to inability to generate positive intra-abdominal pressure and expectorate the secretions. It also increases wound pain, duration of hospital stay, and cost of care due to need for re-suturing under general anesthesia and resources. The patients following burst may require ventilator support also.

We are conscious that the results of the present study are influenced by several limitations. The first limitation regards the population of the study: the sample size is small, and moreover, we analysed the patients with different causes of perforation peritonitis subsequently surgeries done by different surgeons. Another important limitation is that we did not take care of other risk factors in development of both early and late complications after surgery. It is necessary to follow the study population further till 2-3 years post laparotomy to get more accurate results regarding late complications like incisional hernia and sinus formation.

## **V. Conclusion**

Trials from Western countries have shown no significant difference in the risk of burst in the interrupted versus continuous methods of suturing.<sup>6</sup> In our trial, a statistically significant difference in the risk of burst was obtained between the continuous and interrupted arms. Although the choice of technique may not be that significant in elective patients who are nutritionally sufficient, do not have any risk factor for dehiscence and are well prepared for surgery, however in Indian setup, it may prove vital in emergency patients, who often turn up late from remote areas and have multiple risk factors (e.g., intraperitoneal sepsis, cough, uremia, wound infection and co-morbid diseases), for developing dehiscence and it is in these cases that we need to apply the suturing method most effective in preventing burst ( Fig 3 & Fig 4). Moreover the strangulation of the sheath with continuous method is the proverbial last straw in precipitating wound failure in such patients (Fig 5).

**Benefit of interrupted X-suture with the principles of vectors**

We have attempted to explain the benefit of this interrupted X-suture with the principles of vectors.<sup>30-31</sup>

**A. Continuous Closure Method**

Figure 3a shows an example of a Continuous Closure Suture commonly used by most surgeons. In this figure, T is the initial tension applied while tying the knots of the suture. It is important to highlight here that since the thread is free to slide through the abdominal wall (polypropylene or nylon are very smooth and virtually glide through the tissue), the thread tension will always be the same throughout the length of the thread. In figure 3a,  $P_h$  and  $P_v$  are the components of the reactive abdominal wall forces caused due to thread tension T in the directions perpendicular and parallel to the incision line respectively. For equilibrium, it is necessary that the resultant  $R_p$  of  $P_h$  and  $P_v$  must be equal and opposite to the resultant  $R_T$  of the tensions T in the two arms of the thread at point A as shown in the figure 3a. Since the tensions in the arms AB and AC of the suture thought to be equal, the orientation of  $R_T$  will always be in the direction bisecting the angle  $\angle BAC$ . The tension in the thread will rise with the increase in the intra-abdominal forces or patient's movement. Now, because of various factors such as non-equality of longitudinal and circumferential stresses, non-homogeneity and an isotropicity of the abdominal wall, it is almost impossible that the resultant of the additional forces generated in the abdominal wall at point A by coughing, flatulence or movement etc. will be in the same direction as that of the force vector  $R_T$  as highlighted in Figure 3a.

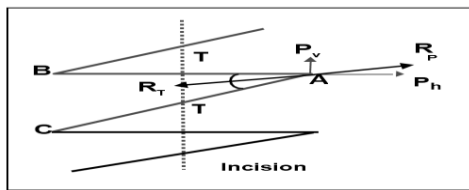


FIGURE 3a: Continuous suture under thread tension only

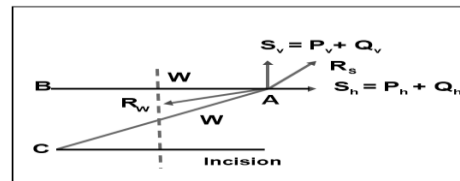


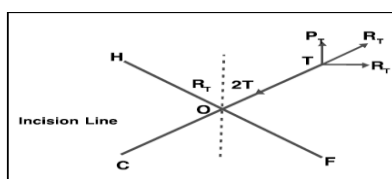
FIGURE 3b: Continuous suture under combined loading of thread tension and intra-abdominal forces

Let  $Q_h$  and  $Q_v$  be the components of the additional forces induced at point A perpendicular and parallel to the line of incision respectively due to intra-abdominal distensions or movements (Figure 3b). To counter balance these additional forces, the tension T in the thread will have not only to increase in magnitude but has also to reorient the direction of the resultant tension  $R_w$ , so as to be just opposite to  $R_s$ , the resultant of  $S_h$  and  $S_v$ . This is so because it is most unlikely (as stated earlier) that the resultant of  $S_h$  and  $S_v$  will also be in the same direction as that of  $R_p$  (or  $R_T$ ) in Figure 3a. Hence the resultant  $R_s$  of  $S_v$  and  $S_h$  (Figure 3b) will mostly be non-collinear to  $R_w$ . The dynamic effect of non co-linearity of  $R_s$  and  $R_w$  will be to cause imbalance between the tensions in the two limbs of the thread at point A leading to slippage of the thread at the suture point as there can't be any differential in the tension in a continuous thread. This leads to distortions in the suture geometry.

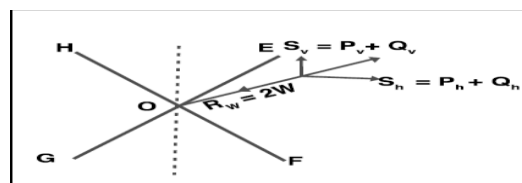
Thus we find that in continuous suture the dynamic changes in the intra-abdominal forces cause “to and fro” movement of the thread causing hacksaw effect on the abdominal wall, leading to distortions in the suture geometry and also leading to additional redundant forces at the suture entry points. It is this “to and fro” motion of the thread (i.e. the hacksaw effect) caused due to the dynamics of abdominal pressures and stretching that makes the continuous sutures of any configuration vulnerable to the cut through phenomena.

**B Interrupted X Suture**

In case of interrupted X suture with a central knot as shown in Figure 4a the problem of non-collinearity of active and reactive forces gets obviated. Because of the central knot in X suture all the four arms namely OE, OF, OG and OH in Figure 4b which are always in tension, are free to rotate about the central knot O - of course subject to the overall equilibrium of the individual X suture block. This freedom of all the four suture limbs to rotate independently about O enables the suture arms to balance the net resultant of the forces on the abdominal wall due to thread tension and coughing, movement etc. without causing any state of redundancy or “to and fro” movement of the thread at suture entry point (Figure 4b). Thus the absence of any hacksaw effect in the X Suture as occurring in continuous suture with every spurt of intra abdominal forces makes the former more efficient and safer than the latter.

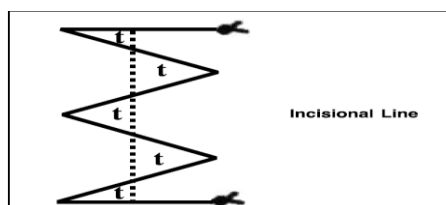


**FIGURE 4a: Interrupted X-Suture under thread tension only**



**FIGURE 4b: Interrupted X-suture under Combined loading of initial thread tension and intra-abdominal forces. Broken line show the original geometry of X-suture under only initial tension T**

Additionally, continuous closure has always been regarded to compromise the blood supply to the healing edges as compared with the interrupted technique. Therefore, interrupted closure has been used to advantage in situations where blood supply is precarious e.g. colon and oesophagus. In Figure 5 the blood supply to the triangles marked “t” is cut off from all sides. This will impair wound healing and thus increase the probability of cut through. In the interrupted X technique since we do not have any horizontal or vertical cross-arms, the blood supply to the healing edge is not impaired leading to decreased probability of cut through and burst abdomen. The hacksaw effect will also occur in other types of continuous sutures (Figure 5).



**FIGURE 5: Continuous suture alternate design**

## Bibliography

- [1]. Gandhi JA, Shinde PH, Digarse RD. Evaluation of Abdominal wall Closure technique in emergency laparotomies at a tertiary care hospital. *Int Surg J* 2016; 3: 1796-1801
- [2]. Ellis H. Midline abdominal incision. *Br J Obstet Gynecol.* 1984;91:1-2.
- [3]. Bucknall TE, Cox PJ, Ellis H. Burst abdomen and incisional hernia: A prospective study of 1129 major laparotomies. *Br Med J (Clin Res Ed)* 1982;284:931-933
- [4]. Webeter C, Neumayer L, Smout R, Horn S, Daley J, Henderson W et al Prognostic models of abdominal wound dehiscence after laparotomy. *J Surg Res* 2003; 109: 130-137
- [5]. Gislason H, Viste A closure of burst abdomen after major gastrointestinal operations- comparison of different surgical technique and later development of incisional hernia. *Eur J Surg* 1999;165:958-961
- [6]. Van't Riet M, Steyerberg EW, Nellensteyn J, Bonjer HS, Jeekel J. Meta Analysis of technique for closure of midline abdominal incisions. *Br J Surg* 2002;89: 1350-1356
- [7]. Smith JAR, Complications: Prevention and Management, *Clinical Surgery in General* 3rd edition, Edinburgh: Churchill-Livingstone 1999; 350
- [8]. Riou JPA, Cohen JR, Johnson H. Factors influencing wound dehiscence. *Am J Surg* 1992;163:324-330.
- [9]. Kumar P, Chaubey D, Sahu SS, Shashi K, Mundu M, Baxia RJ. Comparative study of continuous versus interrupted X type abdominal fascial closure in references to burst abdomen. *Int J Sci Stud* 2014;2:10-16
- [10]. Dudley HA. Layered and mass closure of abdominal wall. A theoretical and experimental analysis. *Br J Surg* 1970;57:664-667
- [11]. Jenkins TP. The burst abdominal wound: A mechanical approach. *Br J Surg* 1976;63:873-876
- [12]. Townsend, Beauchamp, Evers, Mattox. *Sabiston Textbook of Surgery.* 20th ed. Philadelphia; Elsevier; 2016:449.
- [13]. Seiler CM, Bruckner T, Diener MK. Interrupted or continuous slowly absorbable sutures for closure of primary elective midline abdominal incisions: A multicenter randomized trial. *Ann Surg.* 2009;249:576-82.
- [14]. Chowdhary SK, Choudhary SD. Mass closure versus layer closure of abdominal wound: A prospective clinical study. *J Ind Med Assoc* 1994;92:229-232
- [15]. Trimbos JB, Smith IB, Holm JP, Hermans J. A randomized clinical trial comparing two methods of fascia closure following midline laparotomy. *Arch Surg* 1992;127:1232-1234
- [16]. Srivastava A, Roy S, Sahay KB, Seenu V, Kumar A, Chumber S, et al. Prevention of burst abdomen by a new technique: A randomized trial comparing continuous versus interrupted X-suture. *Ind J Surg* 2004; 66: 19-27
- [17]. Agrawal CS, Tiwari P, Mishra S, Rao A, Hadke NS, Adhikari S, et al. "Interrupted Abdominal Closure Prevents Burst: Randomized Controlled Trial Comparing Interrupted- X suture and conventional Continuous Closure in Surgical and Gynecological Patients." *Ind J Surg* 2014;76: 270-276
- [18]. Ahi K S, Khandekar S M, Mittal SK, Chaudhary V, et al. Prevention of Burst Abdomen By Interrupted Closure: "A Comparative Study of Conventional Continuous versus Interrupted-X-Type versus Hughes Far-And-Near Interrupted Abdominal Fascial Closure in Surgical Patients". *IOSR-JDMS e-ISSN: 2279-0853, p-ISSN: 2279-0861. Volume 16, Issue 2 Ver. VII ( February. 2107), pp 21-30.*