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Original Research Article

Postoperative pain and wound complications in pediatric transverse laparotomy: mass closure versus layered closure - a randomized clinical trial

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ABSTRACT

Background: Optimal abdominal wall closure technique in pediatric laparotomy remains debated. This study compared wound complications and postoperative analgesia requirements following mass versus layered closure in children undergoing transverse laparotomy.
Methods: This single-center randomized clinical trial was conducted at the university of Uyo teaching hospital, (UUTH) Nigeria, between 2021 and 2023. Children aged ≤5 years who underwent laparotomy via a transverse abdominal incision were eligible. Excluded were previous laparotomy, abdominal wall defects, or contaminated or dirty wounds. Participants were randomly assigned to either mass or layered closure. In both groups, closure was performed using polyglactin 910 (Vicryl™) sutures by senior surgical trainees under standardized operative and postoperative protocols. Primary outcomes included surgical site infection (SSI), wound dehiscence, incisional hernia, and duration of postoperative analgesia. Follow-up lasted one year. Chi-square, Fisher's exact, and Wilcoxon rank-sum tests were used to compare outcomes between groups, with significance set at $p<0.05$.
Results: A total of 111 children were enrolled (56 mass closure; 55 layered closure). SSI was the most common complication, occurring in 11 patients (9.9%), followed by incisional hernia in 4 (3.6%) and wound dehiscence in 2 (1.8%). Wound dehiscence occurred only in the layered group (n=2, 3.6%), while incisional hernias occurred equally in both groups (n=2 each; 3.6%). Clean-contaminated wounds were significantly associated with SSI (p=0.024), but there were no statistically significant differences in complication rates or analgesia requirements between groups.
Conclusions: Both closure methods appear equally safe in paediatric transverse laparotomy when standard surgical technique is followed. Routine follow-up for at least one year is recommended to detect late complications.

Keywords: Pediatric laparotomy, Abdominal closure, Wound complications, Mass closure, Layered closure, Abdominal surgery, Pediatric surgery, Nigeria

INTRODUCTION

Laparotomy, which is the surgical incision made to access the organs of the abdominal cavity, is among the most frequently performed procedures worldwide.[1,2] It is very common in pediatric surgical practice in our sub-region because of the wide spectrum of intra-abdominal pathology and limited laparoscopic facilities.[3-5] A variety of incisions have been employed for this purpose but the transverse abdominal incision is most commonly used in young children and infants because it offers excellent access to the entire abdominal cavity.[6]

Once a laparotomy wound is created, securely closing the wound is a key step to minimize the postoperative morbidity like incisional hernias, wound infection and

wound pain.[7] This, in turn, may lead to early discharge from the hospital, early return to physical activity and has the potential of eventually saving the overall cost of the procedure. The ideal wound closure provides strength and barrier to infection.[7] Sutures, most commonly, provide mechanical support for the closed wound during its initial healing. They approximate the wound edges and help to maintain wound closure until the healing process provides sufficient strength for the wound to withstand stress and strain.[1]

A key decision during fascial closure is whether to approximate the abdominal wall in multiple anatomical layers (layered closure) or to use mass closure, in which all layers of the fascia, often including the peritoneum, are incorporated into a single suture line. Although various options exist for fascial closure, there remains no definitive consensus on which is superior, particularly in pediatric patients. Previous studies in adults have favored mass closure due to its lower complication rates, particularly for incisional hernias.[7,8] However, there are paucity of studies in the pediatric population. Therefore, the purpose of this study was to objectively determine the most effective technique of abdominal wound closure by comparing clinical outcome parameters between layered closure and mass closure of laparotomy wounds in children.

METHODS

Study setting and design

This study was a hospital-based randomized clinical trial conducted at the UUTH, a 500-bed tertiary referral center located in Uyo, South-South Nigeria. UUTH provides specialist medical and surgical services and serves as a referral center for pediatric surgical cases from within and outside Akwa Ibom State. The hospital supports a catchment population of over six million people. The Pediatric Surgery Unit is staffed by consultant pediatric surgeons, specialist registrars, and trained pediatric nurses, and offers services in general pediatric surgery and pediatric urology. The unit has a dedicated pediatric bed capacity of 150 and records an average of over 100 pediatric laparotomies annually. The study spanned a 24-month period from December 2021 to December 2023, during which patient recruitment occurred over the first 12 months, followed by a 1-year observation period to complete follow-up for the final participants.

Study population and eligibility criteria

The study population comprised children who underwent laparotomy. The Inclusion criteria were children aged between one day and five years who underwent laparotomy by transverse abdominal incision. Exclusion criteria included children with previous laparotomy scars, patients who required reoperation, who had congenital or acquired anterior abdominal wall defects, or who had contaminated, or dirty wounds classified as class III and IV by the centre for disease control and prevention (CDC) surgical wound classification.[9] Children whose parents or guardians declined consent were also excluded.

Eligible patients were enrolled consecutively and randomly assigned to one of two groups. Group A received mass closure of the abdominal wall, while group B underwent layered closure. The study was single-blind: while surgeons could not be blinded to the intervention, the patients and outcome assessors were not informed of the closure method used.

Sample size calculation

The sample size for this clinical trial was estimated using Pocock's formula.[10]

$$n = \frac{(Z_{\frac{\alpha}{2}} + Z_{\beta})^2 \times [p_1(1-p_1) + p_2\,(1-p_2)]}{(p_1 - p_2)^2}$$

Where, $Z_{\frac{\alpha}{2}}$=1.96 for 95% confidence, Z_{β}=0.84 for 80% power, p_1=0.1718, p_2=0.4242.

These proportions were derived from a previous comparative study on pediatric laparotomy wound closure outcomes that reported complication rates of 17.18% in the mass closure group and 42.42% in the layered closure group.[11] The calculated minimum sample size was 48 participants per group (96 total). To allow for a 10% attrition rate, the final sample size was adjusted to 107 total participants.

Surgical procedure

Standard preoperative preparation was provided to all patients. Procedures were performed under general anesthesia with strict adherence to aseptic techniques. In the mass closure group, all layers of the abdominal wall, excluding the subcutaneous tissue and skin, were approximated in a single continuous suture using Vicryl. Bites were placed 1 cm from the wound edge and at 1 cm intervals, locking each bite, and the suture-to-wound length ratio was maintained at a minimum of 4:1. For the layered closure group, the peritoneum and transversalis fascia were closed first, followed by separate closure of the muscle and fascial layers using interrupted sutures. The subcutaneous tissue was approximated with simple interrupted sutures, and the skin was closed using a continuous subcuticular technique in all patients.

Postoperative management included parenteral antibiotics and analgesics until oral intake was tolerated, after which oral paracetamol was administered for five days or longer if required. Pain assessment was conducted using the children and infants postoperative pain scale (ChIPPS).[12] Wounds were routinely assessed on the 5th and 7th postoperative days or earlier if clinical suspicion of infection arose. SSI was diagnosed based on CDC criteria. Other complications such as wound dehiscence,

stitch sinus, and incisional hernia were also documented. Follow-up visits were conducted at 1, 3, and 6 months and 1-year post-surgery to assess for late complications.

Study variables and outcome measures

The independent variable was the abdominal wall closure technique, categorized as either mass closure, defined as a single continuous suture incorporating all fascial layers, or layered closure, involving separate closure of individual abdominal wall layers with multiple sutures.

The primary dependent variables were the postoperative wound complications, defined as follows:

SSI: This was defined using the CDC criteria as infection occurring at the surgical site within 30 days of the procedure, involving purulent discharge, positive wound culture, signs of inflammation, or surgical reopening of the wound in the presence of these signs.

Wound dehiscence: This is complete separation of wound edges, with/without evisceration of abdominal contents.

Stitch sinus: This is a persistent or delayed tract forming around a retained suture, characterized by discharge, typically noted during outpatient follow-up.

Incisional hernia: This is a visible or palpable bulge through a defect at the site of the surgical incision, diagnosed during physical examination during follow-up period.

The secondary dependent variable was the duration of postoperative analgesia, defined as the total number of days analgesics were required following surgery, assessed using the CHIPPS.

Potential confounding variables included nature of surgery (emergency or elective), wound class (Class I: clean; Class II: clean-contaminated), age group, and sex. These were analyzed for associations with wound complications to determine whether they may have independently influenced outcomes.

The primary outcome measure was the incidence of the specified wound complications. The secondary outcome was the duration of postoperative analgesic use. Additionally, associations between closure technique and the selected clinical and demographic variables were evaluated.

Data analysis

Data were recorded in a structured proforma and analyzed using IBM SPSS Statistics version 23 for Windows. Categorical data were presented as frequencies and proportions and analyzed using the chi-square test for normally distributed data or Fisher's exact test for non-normally distributed data. Continuous variables were expressed as means with standard deviations and compared using the student's t test. The Mann Whitney U test was used to compare non-normally distributed variables. A p value of less than 0.05 was considered statistically significant.

Ethical considerations

Ethical approval for the study was obtained from the institutional health research ethics committee of the UUTH (UUTH/AD/S/96/VOL.XIV/575). Written informed consent was obtained from all parents or legal guardians prior to enrolment. Confidentiality was maintained through the use of study identification numbers, and all study procedures adhered to standard surgical and ethical practices.

RESULTS

A total of 111 children who met the inclusion criteria were enrolled and analyzed. Of these, 56 (50.5%) were assigned to the mass closure group and 55 (49.5%) to the layered closure group. The age of patients ranged from 2 days to 60 months (5 years), with a median age of 7 months (IQR: 4-36 months). The majority of patients were infants aged 1 to 12 months (44.1%), and 71 (64.0%) were male.

There were no statistically significant differences between the two groups in terms of baseline characteristics, as shown in Table 1.

Wound complications

The overall incidence of wound complications was 15.3% (n=17). SSI was the most common occurring in 11 patients (9.9%), followed by incisional hernia in four patients (3.6%). There were no statistically significant differences in complication rates between the mass closure and layered closure groups (Table 2).

Association between perioperative factors and surgical site infection

All cases of SSI occurred in children who underwent emergency procedures. However, this association was not statistically significant (p=0.21). Wound class, on the other hand, was significantly associated with SSI. Type II (clean-contaminated) wounds accounted for 81.8% of infections, compared to 18.2% in type I wounds (p=0.024). These associations are presented in Table 3.

Postoperative analgesia

There was no statistically significant difference in the duration of postoperative analgesia between 2 groups. The median duration was 5 days (IQR: 4-6) in both groups (p=0.79), indicating comparable postoperative pain control.

Table 1: Baseline socio-demographic and clinical characteristics of children undergoing laparotomy, by closure technique.

Characteristics	Mass closure, (n=56) (%)	Layered closure, (n=55) (%)	P value	X^2
Age group (in months)				
<1	13 (23.2)	10 (18.2)		
1-12	24 (42.9)	25 (45.5)	0.81	0.43
>12	19 (33.9)	20 (36.4)		
Sex				
Male	39 (69.6)	32 (58.2)	0.21	1.58
Female	17 (30.4)	23 (41.8)		
Type of surgery				
Emergency	50 (89.3)	44 (80.0)	0.17	1.84
Elective	6 (10.7)	11 (20.0)		
Wound class				
Type 1	29 (51.8)	29 (52.7)	0.92	0.009
Type II	27 (48.2)	26 (47.3)		

*X^2 is the Chi-square test statistic

Table 2: Comparison of postoperative wound complications between mass and layered closure techniques.

Complications	Mass closure, (n=56) (%)	Layered closure, (n=55) (%)	P value
SSI	7 (12.5)	4 (7.3)	0.53
Incisional hernia	2 (3.6)	2 (3.6)	0.99
Wound dehiscence	0 (0)	2 (3.6)	0.15
Stitch sinus	0 (0)	0 (0)	-
Wound hematoma	0 (0)	0 (0)	-

Table 3: Association between perioperative factors and SSI.

Factors	SSI present, (n=11) (%)	SSI absent, (n=100) (%)	Total	P value
Nature of surgery				
Emergency	11 (11.7)	83 (88.3)	94	0.21
Elective	0 (0.0)	17 (100.0)	17	
Wound class				
Type I	2 (3.4)	56 (96.6)	58	0.024
Type II	9 (17.0)	44 (83.0)	53	

DISCUSSION

This study aimed to determine the safer method of repair in children by comparing the rate of wound complications and duration of postoperative analgesic use between mass closure and layered closure of the abdominal wall following laparotomy. The findings showed no statistically significant difference in the incidence of postoperative wound complications between the two methods. SSI was the most common complication observed, followed by incisional hernia and wound dehiscence. While all infections occurred following emergency procedures, wound class was the only perioperative factor significantly associated with SSI. Additionally, there was no difference in postoperative analgesia requirements between the two groups, suggesting similar pain outcomes.

There is paucity of studies comparing outcomes of wound closure methods in the pediatric population. A key strength of this study is the consistent use of transverse incisions, same suture material, and surgeon cadre across both groups. This reduced the influence of confounding factors that may have impacted on the results of previous studies. Furthermore, our follow-up extended to one year, which allowed the detection of both early and late postoperative complications that may have otherwise been missed with shorter follow-up periods.

Nevertheless, the study has limitations. The sample size, although sufficient to detect moderate differences in complication rates, may have been underpowered to identify less frequent outcomes such as stitch sinus and incisional hernia. In addition, the study was single-blind, as complete blinding of the surgeons was not possible, potentially introducing performance bias. The one-year follow-up period may also have underestimated the incidence of some late complications such as incisional hernias that may present beyond one year.

In the present study, SSI was the most common postoperative complication. Interestingly, more than half

of the SSI cases occurred in the mass closure group, although the overall difference in infection rates between the two groups was not statistically significant. This pattern is consistent with findings Chalya et al, Bande et al, Maruthi et al and Wante et al who also reported a relatively even distribution of SSIs between closure techniques.[7,11,13,14] In contrast, Hasan et al in a prospective pediatric study, observed an overall SSI rate of 20%, with 75% of infections occurring in the layered closure group (p=0.053).[15] Similarly, Bhavikatti et al found that 30% of their patients in the layered closure group developed wound infections, compared to only 10% in the mass closure group.[16] One possible explanation for the higher infection rates associated with layered closure in these studies may be the increased handling and prolonged exposure of tissue layers during the multilayered repair, which could theoretically promote bacterial contamination. Moreover, both studies included heterogeneous patient populations, many of whom presented with severe intra-abdominal infections and contaminated or dirty wounds, factors that may have independently increased risk of wound infection. The relatively low rate of SSIs observed in our series may be attributed to stricter inclusion criteria, including the exclusion of contaminated or dirty cases.

Incisional hernia and wound dehiscence were relatively uncommon in this study, with no statistically significant differences between closure groups. Similar findings were reported in other studies, which documented low and comparable rates of both complications between layered and mass closure techniques.[13,17,18] In our study, wound dehiscence occurred only in the layered closure group, a finding that aligns with the results of Chalya et al who observed a significantly higher rate of dehiscence among patients who had layered closure. Incisional hernias in our study were observed in both groups at equal frequency.[7] This low occurrence is consistent with findings from Khan et al and Kumar and Hastir where fewer than three cases were reported in each group.[17,18] These outcomes support the view expressed by Fernandez that both closure methods can maintain abdominal wall integrity during healing when performed correctly, using the small bites technique and ensuring minimal tension on the wound.[19] Nevertheless, it remains possible that additional cases of incisional hernia could present beyond the six-month follow-up period used in this study, and longer-term surveillance would be necessary to fully characterize the risk.

Pain management has been infrequently discussed in comparative studies of abdominal wall closure. In our study, the choice of closure technique did not appear to influence pain outcomes, as there was no statistically significant difference in postoperative analgesic requirements between the two groups. This finding agrees with the observations of Singh et al who reported that only one patient in each group experienced persistent pain two weeks after surgery.[20] Similarly, Chalya et al found no significant difference in the duration of postoperative pain or analgesic use between closure groups.[7] However, their study, which focused on adults, did report a significantly higher incidence of wound pain with the use of non-absorbable sutures compared to absorbable ones (p=0.022). These findings suggest that postoperative wound pain may depend more on the type of suture material and the use of appropriate analgesic protocols than on the closure technique itself.

Overall, this study contributes to the limited body of literature from Sub-Saharan Africa on optimal laparotomy closure techniques in children. While it does not support the superiority of one method over the other in terms of wound complications or pain outcomes, it suggests that either technique may be acceptable when applied under controlled surgical conditions. Further multicenter studies with longer follow-up and larger samples are needed to validate these findings and guide evidence-based recommendations for surgical closure in children.

CONCLUSION

In Conclusion, this study showed that both mass closure and layered closure are comparable in terms of postoperative wound complications and pain outcomes in children undergoing laparotomy by transverse incision. Surgical site infections were the most common complication especially following emergency laparotomy and in clean-contaminated wounds. However, there were no statistically significant differences in complication rates between the closure methods. The duration of postoperative analgesic use was also similar between groups.

These findings suggest that either closure technique may be safely adopted in pediatric laparotomy, provided that sound surgical principles are followed. This is especially important in resource-limited settings where factors such as operating time, surgical experience, and the availability of suitable suture materials may influence the choice of closure method. Future multicenter studies involving larger pediatric cohorts and longer-term follow-up are needed to further validate these findings.

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