

# Randomized Trial of Primary Versus Delayed Closure of Contaminated Appendectomy Incisions

Omolabake BI<sup>1</sup>, Ugwu BT<sup>2</sup>.

<sup>1</sup>Surgery Department, Benue State University, Makurdi, Nigeria. <sup>2</sup>Surgery Department, University of Jos, Jos, Nigeria.

\*Correspondence: Omolabake BI Email: obamidele@bsum.edu.ng, Tel: +2347031323030

Article Submitted: June 2021. Published January 2022.

## ABSTRACT

Wound infection is common following contaminated appendectomy incisions in developing countries with an increased cost of treatment. We set out to determine the wound infection outcome and costs of managing contaminated appendectomy incisions closed primarily as compared to those closed using a technique of delayed primary closure. Forty-nine patients with acute uncomplicated appendectomy were randomized into two groups. The first group had primary closure and the second group delayed primary closure of their incisions following operative management. Postoperative monitoring for wound infection was done for one month. The overall cost of wound management and the length of hospital stay were then determined. Twenty-five (51%) and 24 (49%) matched patients were assigned to the primary and delayed primary closure group respectively. Wound infection in both groups was 20% and 4.2% respectively. The mean cost of wound management was fourteen thousand, seven hundred and sixty-four naira only (N 14,764.00), and twelve thousand, one hundred and forty-eight naira only (N 12,148.33) respectively. The mean length of hospital stay was 3.20 days and 2.58 days respectively. In conclusion, primary closure and delayed primary closure of contaminated appendectomy incisions result in similar wound infection outcomes, cost of wound management and length of hospital stay. However, there was a numerical trend in favour of delayed primary closure when the primary outcomes were considered. We recommend that in operative management of contaminated appendectomy wounds, both methods of wound closure are acceptable and clinical judgement should guide the surgeon's choice.

**Keywords:** Contaminated appendectomy wounds, Primary closure, Delayed primary closure, Cost of wound management.



### Article Access

Website: [www.wjmb.com](http://www.wjmb.com)

 [10.5281/zenodo.5934109](https://doi.org/10.5281/zenodo.5934109)

### How to cite this article

Omolabake BI, Ugwu BT. Randomized Trial of Primary Versus Delayed Closure of Contaminated Appendectomy Incisions. *West J Med & Biomed Sci* 2022; 3 (1). 41-50 DOI: [10.5281/zenodo.5934109](https://doi.org/10.5281/zenodo.5934109)

## INTRODUCTION

Surgical wounds are categorized based on their potential for contamination into clean, clean-contaminated, contaminated and dirty wounds.<sup>1</sup> Surgical wound infection often complicates contaminated and dirty wounds. Consequently, efforts have been made over centuries to define methods of management of such wounds to improve wound infection rates and other outcomes.<sup>2</sup> Various wound closure techniques have been described in the management of these wounds. Delayed primary closure and secondary closure were used in managing contaminated abdominal wounds sustained in the war fields, as these were associated with massive contamination and therefore judged to be unsuitable for primary closure.<sup>2,3</sup> These principles were then extended to civilian practice, which is characterized by similar contamination though of lesser magnitude.<sup>2</sup> It involves leaving the wound open initially, to ensure adequate drainage of wound contaminants.<sup>2</sup> However, there are problems associated with this form of wound management. These include patient discomfort from multiple dressing changes, potential exposure of the wound to infective materials during dressing changes in the ward, psychological effects to patients resulting from the raw appearance of the wound, the need for another procedure to close the wound thereby increasing cost, prolonged wound care and often, the need to remain in the in-patient service.<sup>4</sup> Primary closure involves the apposition of the layers of the wound at the time of surgery. Traditional surgical principle stipulates that this should only be applied to clean wounds as it had been earlier observed that primary closure of contaminated wounds was associated with a high rate of wound infection.<sup>2</sup>

The view that primary closure of contaminated abdominal incisions is inappropriate may no longer be tenable in the light of more recent studies.<sup>4,6</sup> This has resulted from improvements in operative techniques, tissue handling and better understanding of the factors

that influence the progression of wound contamination to wound infection.<sup>7</sup> For instance, pre-operative antibiotic prophylaxis is now routinely administered and surgical techniques/wound handling is now more refined. Recent studies indicate that primary closure and delayed primary closure of contaminated abdominal wounds give equivalent wound infection rates.<sup>8,9</sup> Yet, others have found primary closure to be superior.<sup>7,10-11</sup> Primary closure offers several advantages over traditional delayed primary closure including a more convenient management plan, better patient acceptance, less patient discomfort, reduced cost of managing the wound and reduced length of hospital stay.<sup>7</sup> Primary closure also significantly reduces the relative risk of wound failure after closing contaminated abdominal incisions.<sup>10</sup> These might explain the observation that primary closure of contaminated abdominal wounds is widely practised currently.<sup>9</sup> Studies have shown that this is an acceptable practice in the West African sub-region which is characterized by a high burden of wound infection.<sup>6,12</sup> Several factors are associated with the development of infection in contaminated abdominal wounds and of these, the method of wound closure has been shown by previous studies to be critical in determining whether or not such wounds become infected.<sup>13-14</sup>

Acute appendicitis is the leading cause of emergency surgical admission in Nigeria, accounting for 15-40% of emergency surgeries done in many Nigerian centres.<sup>15</sup> There is a high rate of wound infection following contaminated appendectomy wounds in our environment.<sup>15-17</sup> Despite the various wound closure techniques described to address the problem of wound infection, there is still no consensus regarding the best method of closing contaminated wounds.<sup>18-19</sup>

This study aimed to determine the overall wound infection rate and associated cost of managing contaminated appendectomy incisions closed primarily as compared to those closed by delayed primary closure at

Jos University Teaching Hospital, Jos, Nigeria. The specific objectives were to determine the rate of surgical wound site infection using primary closure as compared to delayed primary closure of contaminated appendectomy incisions; to determine the direct cost implications of primary closure of contaminated appendectomy wounds as compared to delayed primary closure, and to determine and compare the length of hospital stay in both groups.

## MATERIALS AND METHODS

This was a randomized controlled study on patients with contaminated appendectomy wounds who gave informed consent.

The exclusion criteria included patients anticipated to have contaminated appendectomy wound, but which turned out to be clean-contaminated, or dirty even if they gave consent previously, patients who developed intestinal fistula through the incision, patients who died before the end of the surgery, or within 72 hours of surgery, and patients with diabetes mellitus, known HIV, malignancies and other immunocompromised individuals as these predispose to wound infections.

The sample size was calculated using the formula:

$$n1 = n2 = [(2p_m q_m)^{1/2} z_{1-\alpha/2} + (p_1 q_1 + p_2 q_2)^{1/2} z_{1-\beta}]^2 / \Delta^2$$

This amounted to a minimum of 23 patients per study arm.

**Sampling technique:** The sampling technique was a randomized technique done with the aid of a computer software<sup>21</sup> such that the entire sample size was randomized between the two study arms before the patients were allocated. As patients were recruited into the study, they were issued a study identification number from one to 50 based on the order in which they presented. This was done in such a way that at the time in which patients were allocated to a study arm, it was not known which group the patient's study identification number fell into- to reduce selection bias. Each patient's

study identification number was then cross-checked against the random table generated by the computer software to determine which study arm he or she fell into.

**Study procedure and data collection:** The study patients were recruited, adequately prepared for surgery and informed and written consent was obtained. The American Society of Anaesthesiologists (ASA)<sup>1</sup> status as determined by the anaesthetist was noted. The patients went through a standardized protocol of surgery which differed only by the method of wound closure. The protocol included observing strict asepsis, administration of general anaesthesia and prophylactic antibiotics (ceftriaxone and metronidazole at standard doses) given intravenously at the time of induction, skin preparation with one percent chlorhexidine and methylated spirit, use of a surgical blade for skin incision and diathermy for deeper layers of the wound. The wound was protected with gauze to reduce contamination and appendectomy was performed using standard technique.<sup>22</sup> For incisions placed in the right lower quadrant, a layered closure was done. When the incision was a midline incision, masse closure technique of the fascio-muscular layers was done. The primary closure group had the skin and subcutaneous layers of the wound closed at the time of surgery using interrupted nylon 2/0 sutures placed a centimetre from the wound edges and a centimetre apart. The wound was then covered lightly with a 10% povidone-iodine soaked gauze. In the delayed closure group, the skin and subcutaneous layer were packed with a 10% povidone-iodine soaked gauze and then a sub-cuticular nylon 2/0 suture was applied loosely, leaving the wound edges open (Figure 1). Both groups of wounds were then covered with a firm but light dressing. The duration of surgery was noted for each participant.

Post-operatively, all the participants were continued on intravenous maintenance fluid and intravenous antibiotics and analgesia. Oral intake was commenced as appropriate when there was evidence of resumption of bowel function. The drugs were then converted to oral medications. Post-operative monitoring of temperature,



**Figure 1:** Delayed primary closure of contaminated wound following emergency appendectomy

radial pulse, blood pressure and appearance of wound dressing was done daily. The wounds were inspected on postoperative day three, but earlier if there was obvious drainage from the wound or wound infection was suspected from the odour or appearance of the wound dressing or the patient exhibited persistent systemic signs such as fever or tachycardia. In this case, the dressing was changed as often as the clinical scenario demanded. The wound was then re-inspected on postoperative day three. When the wound in the primary closure arm was clean on inspection, the wound dressing was changed and the patient followed up in the clinic. Where the wound in the delayed closure arm was clean on inspection, the wound was closed at the bedside by removing the povidone-iodine soaked gauze and pulling the ends of the subcuticular suture after administering 30mg of pentazocine intravenously. Wound dressing was then applied and the patient was discharged with sutures removed seven to ten days later. Postoperative antibiotics and analgesia were given for a total of five and seven days respectively unless wound infection occurred, in

which case they were given as required. In both groups, wound infection was defined as discharge of purulent material from the superficial or deep layers of the wound with or without microbiologic evidence of infection.<sup>1,20</sup> Surveillance for wound infection was done by observing all study patients daily (for symptoms and signs of wound infection using the CDC criteria for incisional SSI<sup>1,20</sup>) until they were discharged and subsequently in the clinic for at least one month after definitive wound closure. Infected wounds in both arms had wound swabs taken for microscopy, culture and sensitivity; they were then opened and packed with the commencement of twice-daily saline dressing. The wound was then secondarily closed when it appeared clean on inspection. Secondary wound closure was done in theatre under strict aseptic conditions using interrupted nylon 2/0 sutures which were removed seven to ten days later.

The direct cost of wound management after the initial surgical procedure was estimated for all study participants. This was done by adding the cost of dressing service, dressing materials, hospital bed cost per day,

analgesia for pain, any secondary wound procedures, analgesia/anaesthesia required and treatment of any associated wound infection including the cost of antibiotics and/or surgical drainage.

The length of hospital stay was also determined for each study participant. This was defined as the number of days spent in the hospital from initial surgery to discharge. All data were recorded in a purpose-designed proforma.

**Data analysis:** All the data obtained from the study were subjected to statistical analysis using the Statistical Package for Social Sciences (SPSS) version 21 statistical software. Results were presented using descriptive statistics, tables and charts. Chi-square/Fisher's exact test and students' T-test statistics were used for analysis with the assistance of a statistician. A p-value < 0.05 was used as the level of significance.

**Ethical considerations:** Permission to conduct this study was obtained from the Research and Ethical Committee of Jos University Teaching Hospital (JUTH). Informed consent and/or assent was obtained from all the patients who met the criteria for inclusion in the study. The results of each patient evaluation were treated confidentially and no financial obligations pertaining to this study was borne by the patient.

## RESULTS

Forty-nine patients were studied with a mean age of 23.8 ± 10.4 years and an age range of 10-50 years. Of the 49 patients, 18(37%) were children aged 10 to 17 years and 31(63%) were adult patients aged 18 years and above. In total, there were 27(55%) females and 22(45%) male patients with a male to female ratio of 4:5. There were more patients in the second decade of life than any other age group. These are summarized in Table 1 & Figure 2.

Twenty-five (51%) patients had their wounds closed using the primary closure while 24(49%) patients had delayed primary closure methods. Of those that had primary closure, 16(64%) were adults and 9(36%) were

children while among those that had delayed primary closure, 15(62%) were adults and 9(38%) were children. Both study groups were matched for age (p=0.26) and gender (p=0.06).

All the patients included in the study had emergency open appendicectomy for uncomplicated acute or recurrent acute appendicitis. All the patients in this study were graded as ASA 1E. Regarding the incisions used for the emergency appendicectomy, 5(10.2%) were lower midline, 14(28.6%) were grid-iron, 30(61.2%) were Lanz. There was no difference between incision used and type of closure (p=0.09). The mean duration of surgery for the primary closure group was 64.0 +/- 26.0 minutes while that for the delayed primary closure group was 84.0 +/- 19.0 minutes (p=0.01).

The mean postoperative days of definitive wound closure were 2.0 +/- 3.9 and 3.4 +/- 2.0 days for the primary closure and delayed primary closure groups respectively (p=0.12) while the mean day of stitch removal was 9.8 +/- 3.9 and 10.7 +/- 2.1 days respectively for the primary closure and delayed primary closure groups (p=0.32).

Six (12.2%) out of 49 patients studied had wound infection. In the primary closure group (n=25), 5(20.0%) of the wounds were infected while in those closed by delayed primary closure (n=24), 1(4.2%) wound got infected. There was no significant association between the method of wound closure and wound infection (p = 0.09, Table 2).

A microbiological study was done on all the infected wounds. In the primary closure group, 4 of the 5 infected wounds (80%) cultured coliforms (*Escherichia coli* and *Klebsiella spp.*). In the delayed primary closure group, the only wound infection cultured *Staphylococcus aureus*. The sensitivity pattern of these microbes indicated resistance to commonly prescribed antibiotics with 4(80.0%) isolated microbes resistant to ampicillin and 3(60.0%) microbes resistant to gentamicin.

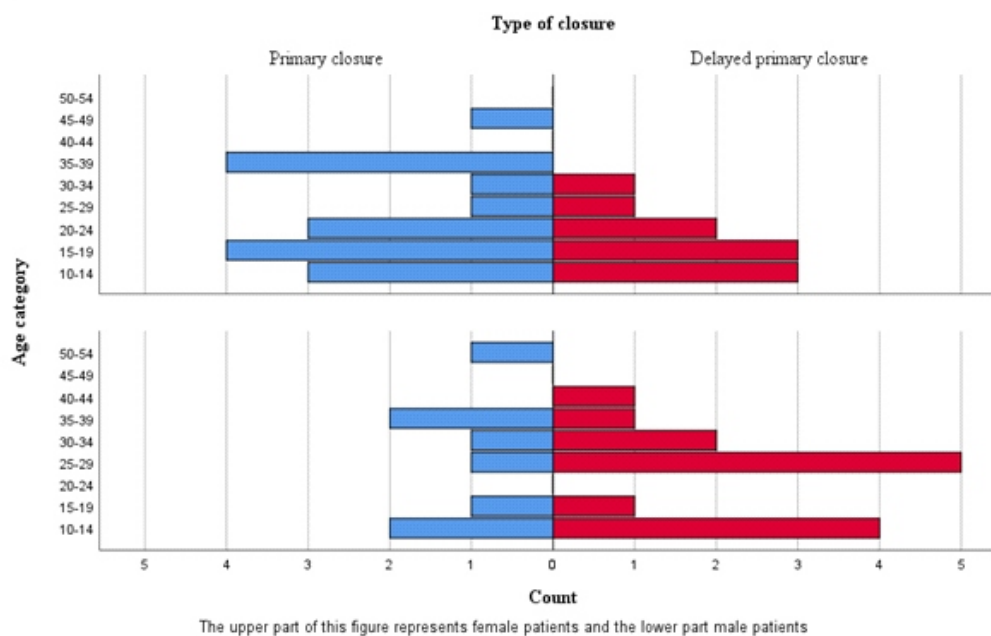
In terms of the direct cost of wound care, the mean cost of primary wound closure and zip closure in this study was N14,764.00 +/- 10,250.02 and N12,148.33 +/- 9,172.71 respectively. The difference was however not statistically



significant (p=0.35). See table 3. The mean length of hospital stay for patients in the primary closure group and delayed primary closure group was 3.20 +/- 2.89 and 2.58 +/- 2.86 days respectively. This was also not statistically significant (p=0.46) as shown in Table 4.

**Table 1: Gender of study participants versus type of wound closure**

| Gender       | Type of closure |                         | Total            |
|--------------|-----------------|-------------------------|------------------|
|              | Primary closure | Delayed primary closure |                  |
| Female       | 17 (35%)        | 10 (20%)                | 27 (55%)         |
| Male         | 8 (16%)         | 14 (29%)                | 22 (45%)         |
| <b>Total</b> | <b>25 (51%)</b> | <b>24 (49%)</b>         | <b>49 (100%)</b> |



**Figure 2: Patient demographics: Age category, gender and type of wound closure**

**Table 2: Postoperative wound infection versus type of wound closure**

| Postoperative Wound Infection | Type of closure |                         | Total     |
|-------------------------------|-----------------|-------------------------|-----------|
|                               | Primary closure | Delayed primary closure |           |
| No                            | 20              | 23                      | 43        |
| Yes                           | 5               | 1                       | 6         |
| <b>Total</b>                  | <b>25</b>       | <b>24</b>               | <b>49</b> |

$\chi^2=2.857$   $df=1$   $p=0.091$

**Table 3: Cost of wound care versus type of wound closure**

| Type of closure         | N  | Mean cost of wound closure N(US\$) | Standard deviation | Standard error of mean |
|-------------------------|----|------------------------------------|--------------------|------------------------|
| Primary closure         | 25 | 14,764.00(74.34)                   | 10,250.02          | 2,050.00               |
| Delayed primary closure | 24 | 12,148.33(61.17)                   | 9,172.71           | 1,872.37               |

$t=0.940$   $df=47$   $p=0.352$   $CI: -2,982.58$  to  $8,213.91$ .

**Table 4: Length of hospital stay versus type of wound closure**

| Length of hospital stay | N  | Mean (days) | Standard deviation | Standard error of mean |
|-------------------------|----|-------------|--------------------|------------------------|
| Primary closure         | 25 | 3.20        | 2.89               | 0.58                   |
| Delayed primary closure | 24 | 2.58        | 2.86               | 0.58                   |

t=0.751 df= 47 p=0.46 CI: -1.035 to 2.268

## DISCUSSION

The overall wound infection rate of 12.2% in this study is similar to that reported by Cruse and colleagues<sup>23</sup> for contaminated wounds. The finding of a 20% wound infection rate in the primary closure group is similar to that found by Tsang and co-workers<sup>24</sup> in contaminated appendectomy wounds. However, the finding of a 4.2% wound infection rate for delayed primary closure is lower than that of similar studies.<sup>24-26</sup>

There was no difference in the rate of infection between the two groups, similar to results found by other authors<sup>24-25</sup> but at variance with findings of other workers.<sup>13,26-27</sup> The latter may be explained by differences in the specific technique of delayed primary closure utilized in the studies for example povidone-iodine was applied between the wound edges in this study, which was not the case in others.

Improvements in surgical techniques and routine use of prophylactic antibiotics may account for the increasingly acceptable wound infection outcome after primary closure of contaminated appendectomy wounds<sup>7,28</sup> as compared to delayed closure.

The organisms responsible for wound infection in the primary closure group were mostly coliforms, similar to the findings of other authors.<sup>29-30</sup> This suggests intraoperative contamination of the wound and hence the need to protect the access wounds from inflamed viscus and/or spilt bowel contents. In contrast, the wound infection noted in the delayed primary closure group was by *Staphylococcus aureus*, suggesting an exogenous source from contamination by skin organisms. In comparison, Olu-bode<sup>29</sup> reported that 25% of wound infection following delayed primary closure was caused by *Staphylococcus* organisms. Possible sources may be

from breaches in asepsis during surgery and/or wound management in the ward. Ussiri and colleagues<sup>11</sup> earlier noted that the environment and patients' skin are important sources of wound infection. Bacteria can also be suspended in the air especially in dusty seasons and these can contaminate surgical wounds.<sup>31</sup> The significance of this is that wound infection following delayed primary closure may be reduced further if secondary wound procedures like dressing changes are done in a more controlled environment, compared to the open ward.

Most of the organisms isolated were resistant to ampicillin and gentamicin, which are commonly prescribed antibiotics. This is similar to the findings of others<sup>29,32</sup> and reflects patterns of antibiotic abuse.

The direct cost of managing both groups of wounds was also found to be similar, in keeping with findings of a similar study.<sup>13</sup> This is not surprising, given the fact that wound infection is a major contributor to the cost incurred in managing surgical patients.<sup>9,33-34</sup> This observation is important as clinical decisions are not uncommonly influenced by economic considerations.

The length of hospital stay was used as a 'surrogate' for indirect costs in this study, similar to that done by Khan and colleagues.<sup>9</sup> There was no difference between the two groups in this study as with similar studies.<sup>9,13</sup> The length of hospital stay is influenced by occurrence of wound infection<sup>9,33-34</sup> as an infected wound will require additional wound management which may prolong hospital admission. As the wound infection rate is similar between both groups, this finding is expected.

The duration of surgery was noted to be significantly longer in the delayed closure group. The reason for this

observation is unknown, but a possible explanation is that the technique of delayed primary closure described in this study required a learning curve as it is not a routinely performed wound closure technique.

This study has shown that delayed primary closure of contaminated appendectomy incisions is statistically similar to primary closure in terms of wound infection rates, direct and indirect costs incurred. However, there is a numerical trend in favour of delayed closure. This suggests that there may still be a role for delayed closure of contaminated appendectomy wounds. As such, sound judgement in the specific circumstance and prior experience are important in guiding intraoperative decision making.

Failure to include anaerobic culture has been identified as a weakness of this study and should be considered in similar studies in the future. Also, the study was homogenous- emergency open appendectomy making up all the cases, which may not reflect the problem posed by a more heterogeneous spectrum of contaminated abdominal wounds. In addition, dirty wounds pose a bigger wound infection challenge and it is desirable if future studies consider this sub-set of wounds. The suggestion that delayed primary closure is less convenient may need to be tested in future designs as well as the cosmetic outcome of the resulting surgical scar- as these are often important patient considerations.

## CONCLUSION

This study has demonstrated that primary closure and delayed primary closure of contaminated appendectomy incisions are equivalent in terms of surgical wound infection rates, direct cost of wound management and length of hospital stay despite a numerical trend in favour of delayed primary closure. However, delayed primary closure was associated with a significantly longer operating time compared to primary closure.

## Recommendation

We recommend that in operative management of contaminated appendectomy wounds, both methods of wound closure are acceptable and clinical judgement should guide the surgeon's choice.

## REFERENCES

1. Mangram A, Horan T, Pearson M, Silver S, Jarvis W. Prevention of surgical site infection. *Infect Control Hosp Epidemiol.* 1999;20(4):24778.
2. Collier F, Valk W. The delayed closure of contaminated wounds. *Ann Surg.* 1940;112(2):25670.
3. Manring MM, Hawk A, Calhoun JH, Andersen RC. Treatment of war wounds: A historical review. *Clin OrthopRelat Res.* 2009;467(8):216891.
4. Burnweit BC, Bilik R, Shandling B. Wounds in Perforated Appendicitis. *J Pediatr Surg.* 1991;26(12):13625.
5. Ussiri E, Mkony C, Aziz M. Surgical wound infection in clean-contaminated and contaminated laparotomy wounds at Muhimbili National Hospital. *East Cent African J Surg.* 2005;10(2):1923.
6. Usang UE, Sowande OA, Ademuyiwa AO, Bakare TB, Adejuyigbe O. Outcome of primary closure of abdominal wounds following typhoid perforation in children in Ile-Ife, Nigeria. *Afr J Paediatr Surg.* 2009;6(1):314.
7. Rucinski J, Fabian T, Panagopoulos G, Schein M, Wise L. Gangrenous and perforated appendicitis: a meta-analytic study of 2532 patients indicates that the incision should be closed primarily. *Surgery.* 2000;127(2):13641.
8. Siribumrungwong B, Noorit P, Wilasrusmee C, Thakkestian A. A systematic review and meta-analysis of randomised controlled trials of delayed primary wound closure in contaminated abdominal wounds. *World J Emerg Surg.* 2014;9(1):4957.
9. Khan KI, Mahmood S, Akmal M, Waqas A. Comparison of rate of surgical wound infection, length of hospital stay and patient convenience in



- complicated appendicitis between primary closure and delayed primary closure. *J Pak Med Assoc.* 2012;62(8):5968.
10. Henry MW, Moss RL. Primary versus delayed wound closure in complicated appendicitis: An international systematic review and meta-analysis. *PediatrSurg Int.* 2005;21(8):62530.
  11. Ussiri E, Mkony C, Aziz M. Sutured and Open Clean-Contaminated and Contaminated Laparotomy Wounds at Muhimbili National Hospital: A Comparison of Complications. *East and Central African J Surg* 2004; 9(2): 89-95.
  12. Ameh EA, Mshelbwala PM, Nasir AA, Lukong CS, Jabo BA, Anumah MA, et al. Surgical site infection in children: prospective analysis of the burden and risk factors in a sub-Saharan African setting. *Surg Infect (Larchmt).* 2009;10(2):1059.
  13. Cohn SM, Giannotti G, Ong AW, Varela JE, Shatz D V, Mckenney MG, et al. Prospective Randomized Trial of Two Wound Management Strategies for Dirty Abdominal Wounds. *Ann Surg.* 2001;233(3):40913.
  14. Oliver J, Al-Mufti R. The prolene zip technique: prevention of wound infections in contaminated abdominal incisions. *Ann R Coll Surg England.* 2005;87:3834.
  15. Alatise O, Ogunweide T. Acute Appendicitis: Incidence and Management in Nigeria. *J Obafemi Awolowo Univ Med Student's Assoc.* 2008;14(1):66-70
  16. Ali N, Aliyu S. Appendicitis and its surgical management experience at the University of Maiduguri Teaching Hospital Nigeria. *Niger J Med.* 2012;21(2):2236.
  17. He JC, Zosa BM, Schechtman D, Brajceich B, Savakus JC, Wojahn AL, et al. Leaving the Skin Incision Open May Not Be as Beneficial as We Have Been Taught. *Surg Infect (Larchmt).* 2017;18(4). 431-9
  18. Osakwe JO, Nnaji GA, Osakwe RC, Agu U, Chineke HN. Role of premorbid status and wound related factors in surgical site infection in a tertiary hospital in sub-saharan Africa. *Fam Pract Reports.* 2014;1(1):17.
  19. Duttaroy DD, Jitendra J, Duttaroy B, Bansal U, Dhameja P, Patel G, et al. Management strategy for dirty abdominal incisions: primary or delayed primary closure? A randomized trial. *Surg Infect (Larchmt).* 2009;10(2):12936.
  20. Gottrup F, Melling A, Hollander D. An overview of surgical site infections: aetiology, incidence and risk factors. *EWMA J.* 2005;5(2):115.
  21. Urbaniak GC, Plous S. Research Randomizer version 4.0 Computer software (2013). Date accessed:Feb. 8th 2018. Available at: <http://www.randomizer.org/>.
  22. Farquharson M, Brendan M. Classic operations on the small and large bowel. In: Margaret F, Brendan M, editors. *Farquharson's textbook of operative general surgery.* 9th ed. London: Edward Arnold (Publishers) Ltd; 2005. p. 37983.
  23. Cruse PJ, Foord R. The epidemiology of wound infection. A 10-year prospective study of 62,939 wounds. *Surg Clin North Am.* 1980;60(1):2740.
  24. Tsang TM, Tam PK, Saing H. Delayed primary wound closure using skin tapes for advanced appendicitis in children. A prospective, controlled study. *Arch Surg.* 1992;127:4513.
  25. Siribumrungwong B, Srikuea K, Thakkinstian A. Comparison of superficial surgical site infection between delayed primary and primary wound closures in ruptured appendicitis. *Asian J Surg.* 2014;37:1204.
  26. Pettigrew RA. Delayed primary wound closure in gangrenous and perforated appendicitis. *Br J Surg.* 1981;68(1981):6358.
  27. Chatwiriya Charoen W. Surgical wound infection post surgery in perforated appendicitis in children. *J Med Assoc Thai.* 2002;85(5):5726.
  28. Tobin R. Closure of contaminated wounds. Biologic and technical considerations. *Surg Clin North Am.* 1984;64(4):63952.

29. Olu-bode C. Primary versus Delayed primary closure in Dirty Abdominal wounds. Dissertation. National Postgraduate Medical College of Nigeria; 1991. p.1-60
30. Chiang RA, Chen SL, Tsai YC. Delayed primary closure versus primary closure for wound management in perforated appendicitis: A prospective randomized controlled trial. *J Chinese Med Assoc.* 2012;75(4):1569.
31. Shuaibu AS, Ibrahim YE, Olayinka BO, Atata RF, Oyeniyi J, Shuaibu BA. Retrospective Study on the Prevalence of Surgical Wound Infections in Specialist Hospital Sokoto North West Nigeria. *J Adv Med Pharm Sci.* 2017;13(2):1-7.
32. Inyang AW. Primary versus Delayed Primary closure of laparotomy wounds in children following Intestinal perforation in Ile-Ife. Dissertation. National Postgraduate Medical College of Nigeria; 2010. p.1-43
33. Ahmad M, Ali K, Latif H, Naz S, Said K. Comparison of Primary Wound Closure With Delayed Primary Closure in Perforated Appendicitis. *J Ayub Med Coll Abbottabad.* 2014;26(2):1537.
34. Jenks PJ, Laurent M, McQuarry S, Watkins R. Clinical and economic burden of surgical site infection (SSI) and predicted financial consequences of elimination of SSI from an English hospital. *J Hosp Infect.* 2014;86:2433.