(xiv) HIV

Ferguson [56] assessed the role of the general surgeon in the care of patients with AIDS and AIDS-related complications who underwent major abdominal operations. The results showed that the indications for operation were;

Gastrointestinal perforation of ileum and colon by CMV

AIDS related immune thrombocytopenia leading to splenectomy for ITP

Gastrointestinal complications of opportunistic infections and neoplasms such as tuberculosis, Kaposis sarcoma, lymphoma leading to bowel obstruction.

Retroperitoneal lymphadenopathy

Cryptosporidium cholecystitis

Emparan et al [57] determined the influence of low CD4 lymphocytes count in 24 patients with HIV undergoing abdominal surgery after receiving selective antibiotic prophylaxis depending on the surgical procedure performed. Results revealed a high overall wound infection rate accounting for 58.3%. Among those patients who developed wound infection, mean CD4 count was 221 versus 386 of uninfected group. Wound infection rate for clean wounds was 50%, clean-contaminated wound was 62.5% and contaminated wound was 62.5%.

Davis *et al* [58] reviewed the incidence of wound complications following laparotomy for HIV positive patients and compared with non HIV patients. The results showed a significantly greater incidence of wound complication (P=0.0003) and wound breakdown (P=0.012) in the HIV group than on the non-HIV control group.

Morandi *et al* [59] studied the healing time after haemorrhoidectomy in 48 patients with HIV infection and AIDS. The results showed the healing rate in HIV-positive patients to be 66% after 14 weeks and 100% after 32 weeks; compared to 0% and 50% for patients with AIDS. All controls were healed after 14 weeks. This difference was statistically significant (P<0.01). It was concluded that indications for haemorrhoidectomy in patients with AIDS need to be considered extremely carefully because of high incidence of delayed wound healing.

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1.2.2 SURGICAL WOUND INFECTION

(i) Historical perspectives

The first step against wound infections and asepsis occurred in the mid-1800s, when Semmelweis introduced the association of handwashing with decreased bacterial contamination [1,20]. Pasteur [1] in 1865 introduced a theory of putrefaction which revealed that purulence was caused by microorganisms. Later Lister [20] in 1867, introduced the use of carbolic acid spray on the entire operating room, patient and surgeons. This reduced dramatically the rates of wound infection.

Penicillin was the first antibiotic to be discovered in 1948 [60]. Thereafter a variety of antibiotics with wide coverage range have been discovered and used to prevent and treat surgical wound infection. Before 1980s antibiotics were administered postoperatively but later found that perioperative administration was more effective in preventing surgical wound infection.

(ii) Bacterial colonization and invasion

Surgical wound infection is clinically defined as evidence of purulent discharge with classical signs of erythema, induration and tenderness [61].

Bacteriologically, the surgical wound is considered to be infected when a culture yields bacteria count of more than 10^5 cfu/gm of tissue or ml of fluid. Herrera-Hernandez et al (18) evaluated the value of soft tissue biopsy culture on contaminated or infected open surgical wounds and found that among those patients (35%) who developed wound infection the culture yielded bacterial count of more than 10^5 cfu per gramme of tissue.

Tonnelli [19] recommended a prolonged course of antibiotic therapy in contaminated wound with bacterial count of more than 10^5 cfu per ml of fluid or gramme of tissue as the infection will occur.

Mertz et al [62] found that acute wounds harbour microflora similar to that of uninjured skin while dirty, traumatic or chronic wounds offer more opportunity for microflora colonization. Wound infection occurs only when bacteria on the wound invade viable tissue and evade the host defense response.

(iii) Classification of Surgical wounds and risk of infection

Cruse and Foord [63] studied the epidemiology of surgical wound infection and classified surgical wounds into four categories as follows;

Clean wounds:

These are elective, non emergency, nontraumatic, primarily closed wounds; no acute inflammation, no break in technique, respiratory, gastrointestinal, biliary and genitourinary tracts not entered.

Risk of infection is less than 2%.

Clean-contaminated wounds:

These are wounds resulting from urgent or emergency cases that are otherwise clean; elective opening of respiratory, gastrointestinal, biliary or genitourinary tract with minimal spillage (for example appendectomy) not encountering infected urine or bile; minor technique break.

Risk of infection is less than 10%.

Contaminated wounds:

These are wounds resulting from non-purulent inflammation gross spillage from gastrointestinal tract; entry into biliary or genitourinary tract in the presence of infected bile or urine; major break in technique; penetrating trauma <4 hours old; chronic open wounds to be grafted or covered.

Risk of infection is approximately 20%.

Dirty/infected wounds:

These are wounds resulting from purulent inflammation (for example, abscess); preoperative perforation of respiratory, gastrointestinal, biliary or genitourinary tract; penetrating trauma >4 hours old.

Risk of infection is approximately 40%.

However, other studies have shown variation in wound infection rates. Kotisso and Aseffa [64] studied the magnitude and pattern of surgical infection on 129 patients following abdominal operations in Ethiopia . The results show that the overall wound infection rate was 21% and this was significantly associated with the class of wound, highest rate being 61.4% for contaminated or dirty wound.

A study from Sri Lanka by Rajasegaram et al [65] revealed high rates of surgical wound infection, 15% for clean wounds, and 13% for clean-contaminated wounds. High infection rate for clean wounds was attributed to abdominal packs which were not frequently utilized by surgeons in training, prolonged exposure of instruments and towels, re-used gloves, absence of lamina flow systems and high number of medical students. Most of the operations with clean-contaminated wounds were done by specialists. Higher infection rates occurred in

However, a study by Renvall et al [66] on 696 abdominal operations revealed an overall wound infection rate of 9.8%. In this study, the infection rate for clean wounds was 4.2%, clean-contaminated wounds was 9.1%, contaminated wounds was 14.4% and for dirty wounds was 28.8%. These rates were high compared to those found by Abu [67] that is, 2.9 for clean wounds, 5.4% for clean-contaminated wounds, and 15.2% for contaminated wounds and lower than those found by Rajasegaram et al [65] which were 15% and 13% for clean and clean-contaminated wounds respectively.

(iv) Predisposing factors to surgical wound infection

Preoperative shower for patients [68,69]

Preoperative shower reduces the total bacterial count on the skin as well as surgical wound infection. Tunevall [68] found that preoperative shower with chlorhexidine scrub significantly reduces wound infection rates as well as infection associated with central venous catheters. However, when Leigh et al [69] compared total body bathing hibiscrub or non medicated soap in 224 patients admitted for surgery, there was a greater reduction in total bacterial count on the skin and perianal region in patients using hibiscrub but, there was no difference in the rate of wound infection using hibiscrub or ordinary soap.

in patients using hibiscrub but, there was no difference in the rate of wound infection using hibiscrub or ordinary soap.

Shaving [70,71,72,73]

The use of a depilatory cream as an alternative to a razor would seem to have the advantages of increasing patient comfort, of avoiding injuries inflicted by even skilfull shaving , and decreasing the incidence of wound infection [70].

Thur de Koos and Mc Comas [71] randomized 253 patients into preoperative shaving and chemical depilation and found that there was no statistically significant difference in wound infection between the two groups. Brid et al [72] studied the effect of preoperative shaving on clean operations and found that wound infection rate when extensive preoperative shaving was used was 2.9%versus 1.5% when shaving was not used. Pawan [73] found that there was a higher wound infection rate in the razor shaving group than in the depilatory group (21.9% versus 4.7%, $P<0.005$) and shaving more than 24 hours before operation had higher infection rate.

Skin incise drapes [3,4,5,6,7,8,9]

Many studies have been done to determine the role of plastic adhesive skin incise drapes on surgical wound infection with no significant benefit obtained except in one study by Sookhai et al [3] who found a

Dewan et al [4] randomized 1102 patients who underwent abdominal operations for clean and clean-contaminated wounds between those where plastic incise drapes were used and a standard skin preparation technique. Results revealed that incise drapes reduced the contamination of the wound but not the wound infection rate between the two groups.

Nyström and Brote [5] evaluated the effects of a plastic wound drape on wound contaminaton and subsequent infection in 289 appendicectomies and found that wound infection rate in the treatment group was 7.6% versus 9.1% in the control. This difference was not significant.

Lewis et al [6] randomized 45 patients who were to undergo clean elective inguinal operation and found that an incise drape reduced bacterial colony counts but no clinical postoperative wound infections developed in either group.

Nyström et al [7] evaluated the efficacy of plastic wound ring drapes to prevent contamination and infection in 140 elective operations and found that wound infection rate was 10% for those draped versus 9% with no drape. It was concluded that incise drapes do not prevent infection. Ward et al [8] did a randomized trial on 620 patients following caeserean section in South Africa and found that wound infection rate was 11.1% in the test group compared to 10.1% in the control group. This difference was not statistically significant. Similar results were

was 11.1% in the test group compared to 10.1% in the control group. This difference was not statistically significant. Similar results were obtained by Psaila et al [9] when they randomized 144 patients who underwent abdominal surgery.

Prolonged preoperative period [74]

Long preoperative hospital stay has been associated with postoperative wound infection. Hasselgren et al [74] evaluated 1243 operations and found that those patients who had hospital stay more than 24 hours had an infection rate of 12.5% compared to 4.5% for those who had shorter stay of less than 24 hours.

Duration of operation [75]

The longer the duration of operation, the higher the wound infection rate. Miftari [75] evaluated the effect of the duration of the surgical procedure on wound infection in 90 patients. Results revealed that among those patients who had clean wounds, the wound infection rate was 10.5% for procedure longer than 1 hour compared to none for procedure shorter than 1 hour. In clean-contaminated group, the wound infection rate was 50% for procedure longer than 1 hour compared to 10% for procedure shorter than 1 hour. In contaminated group,

It was concluded that, wound infection rate increases if operation takes longer than 1 hour and is even higher if operation is done upon clean-contaminated or contaminated wounds.

Age [25,28,40,41]

Old age has been associated with high wound infection rate due to poor wound healing associated with ischaemic diseases [25,28,40].

Norman et al [41] determined the rate of wound infection after 238 clean operations without using prophylactic antibiotics. Results revealed a high overall wound infection rate of 8%, whereby wound infection rate in elderly (>60 years old) was 25% versus 6% for <60 years old patients (P= 0.011). These findings justified use of prophylactic antibiotic in clean operations in old patients.

Emergency versus Elective operations [64,66,76]

Emergency operations have been associated with high wound infection rate. Renvall et al [66] found the rate of wound infection of 12.4% in acute versus 7.6% in elective procedures in 696 abdominal operations. Israelsson et al [76] in a study on suture technique and wound healing in midline laparotomy incisional wounds found that wound infection rate was 16% in emergency operations compared to 9% for elective operations.

However, Kotisso and Aseffa [64] evaluated surgical wound infection in 129 patients following abdominal operations and found that there was no difference in the wound infection rate between emergency and elective operations.

Wound management [14,15,16,77]

Delayed primary wound closure, for selected clean-contaminated or dirty wounds reduces significantly the rate of wound infection [15]. Meissner and Meiser [14] evaluated patients who underwent emergency abdominal operations and found that the rate of wound infection in the primary skin suture group was 39% compared to none in open skin treatment. Smilanich et al [16] obtained similar results of high infection rate for primary closure (27% versus 3% respectively). It was, therefore, concluded that delayed primary closure remains the optimal method of management for contaminated wounds.

Scott et al [77] studied the influence of wound closure on wound healing and found that, delayed primary closure or secondary closure of skin and subcutaneous fat in contaminated laparotomy incisions eliminates the risk of wound infection and incisional hernia. Open wounds stimulate collagen synthesis and improve wound strength.

Subcutaneous drains [65,78,79,80]

Subcutaneous drains have been applied to reduce wound infection rate. However, current studies revealed that subcutaneous drains predispose to higher wound infection and if at all used one should use a closed suction system of drain. A survey by Rajasegaram et al [65] in wound infection revealed that wound infection rate was higher in the group of wounds where drains were used than for the other group where no drain was applied (17% compared to 10%).

Another study by Magann et al [78] when comparing the rate of wound disruption between closure of the subcutaneous fat with stitch versus subcutaneous drain without stitching following 964 Cesarean sections found that wound disruptions occurred in 9.7% when subcutaneous tissue was stitched compared to 10.4% when subcutaneous drains were used (P= 0.834); the differences were not significant.

In a study by White et al [79] evaluating wound-related complications after incisional hernia repair, found that overall wound infections were more frequent when drains were placed.

Farnell et al [80] when comparing the results of primary closure, subcutaneous catheter irrigated with saline or antibiotic and

catheter alone or with antibiotic or saline was not superior to primary closure for clean-contaminated or contaminated incisions.

Electrocautery/Diathermy [81,82]

Kearns et al [81] compared the effect of electrocautery and blade in the midline incision of 100 patients and found that, there was no significant difference in wound complications.

Arnand and Adloff [82] compared wound healing following incisions made by scapel and diathermy and found no difference in wound strength between scapel and diathermy. It was concluded that in abdominal surgery, diathermy could be used without detriment to the strength of any suture line and with no difference in its final healing.

Suture Technique [76,83,84]

Suture technique play part in the development of wound infection. Israelsson et al [76] studied on 467 midline laparotomy wounds closed by continuous, monofilament, mass closure and found that overweight (body index mass-BIM greater than 25) patients were sutured with a longer stitch and there was a high rate of infection in these patients, 14% versus 8%, $P< 0.05$.

Shittu et al [83] compared the outcome of patients with ruptured gravid uterus following obstructed labour who had abdominal closure by a

simple mass-closure technique using nylon suture with layered closure technique. Results showed that wound infection was high, 32% in layered closure group compared to 19% in mass-closure group.

Similar findings were obtained by Chowdhury et al [84] when compared the complications of mass-closure and layered closure of abdominal wounds in 160 patients and found that the wound infection rate was high, 47.5% in layered closure compared to 22.5% in mass closure ($P < 0.001$).

(v) Consequences of surgical wound infection

Morbidity and mortality

Martnez et al [85] conducted a study on postoperative complications following gastric cancer surgery and found that, morbidity in terms of infection accounted for 17.07% with mortality of 13.33%.

Wagle et al [86] evaluated patients who underwent pancreaticoduodenectomy for periampullary carcinoma; it was found that the commonest morbidity was wound infection, accounting for 46% and mortality by 11%.

McArdle et al [87] did a colorectal surgery on 169 patients with an overall wound infection rate of 17%.

Another study by DiPiro [88] on 12,384 patients found higher rates of postoperative wound infection, 22% following colorectal procedures and 25% following upper gastrointestinal procedures.

A study done by Renvall et al [66] on 696 abdominal operations revealed higher mortality rate due to wound infection, 11.8% versus 1.6% for no wound infection. Sule et al [89] on one stage procedure in management of acute sigmoid volvulus on 30 patients, found that wound infection rate was 13.3% with no mortality.

Costs and hospital stay

Surgical wound infection is associated with high costs to the patient as well as the health sector.

Plowman et al [90] studied 4000 patients and found that surgical wound infection prolonged hospital stay to an average of 15 days with mean cost per patient of £3500. Kirkland et al [91] when determining the morbidity, mortality and costs attributable to surgical wound infection on 255 patients found that there was a high rate of mortality in infected group, 7.8% versus 3.5% for uninfected group. Also, Intensive Care Unit (ICU) admission was 29% for infected group versus 18% for uninfected group, re-admission was 41% for infected group versus 7% for uninfected group and median direct cost of hospitalization was $7531 for infected group versus $3844 for uninfected group.

Tyburski et al [92] when comparing the effectiveness of two regimens of prophylactic antibiotics for penetrating abdominal injuries, found that the overall wound infection was 18%. Infection increased length of hospital stay from 8.7±3.5 days to 23.3±10.9 days and hospital charges from $24507 ± $9860 to 104920 ±49083 (P< 0.001).

Renvall et al [66] found the nursing time for patients with wound infection to be 7 days longer than in the uninfected patients. Similar results were obtained by Kotisso and Aseffa [65] showing that, surgical wound infection accounted for delay in the discharge of 14.7% of patients.

Dehiscence and Incisional hernia

The commonest predisposing factors to the development of wound dehiscence and incisional hernia include surgical wound infection and suture technique. Wound infection is associated with 10-fold increase in the incidence of wound dehiscence and incisional hernia [93].

Chowdhury et al [84] did a controlled clinical trial on 160 patients for a single layer mass-closure with monofilament suture and layer closure with chromic cut-gut. Result showed that wound infection rate was higher when using chromic cut-gut, 47.5% versus 22.5% for monofilament suture. Burst abdomen occurred in 3.8% in chromic cut-gut suture with layered closure and none in monofilament, mass-closure.

Israelsson et al [94] randomized 861 patients following midline laparotomy wound closure with monofilament, 1/0 nylon continuous , mass-closure with follow-up of 12 months. The results revealed an overall rate of burst abdomen of 0.6% and incisional hernia of 15%. Incisional hernia was related to wound infection and suture length-wound length ratio such that, presence of infection contributed to incisional hernia in 27% compared to 14% for no wound infection. The rate of incisional hernia for those sutured with suture length-wound length ratio of less than 4 was 22% compared to 9% for those sutured with suture length-wound length ratio of or more than 4.

Another study by Israelsson et al [76] on 467 patients studied the influence of suture technique on healing of midline laparotomy wound closure by continuous, monofilament, mass closure with follow up of 12 months found that the overall rate of wound infection was 11%, overall wound dehiscence was 0.4% and this was associated with wound infection, and an overall incisional hernia was 11%. Among those patients with incisional hernia, suture length : wound length ratio of, less than 4 accounted for 18%, 4 to 4.9 accounted for 5% and of 5 or more accounted for 12%.

Therefore, the optimal suture length : wound length ratio recommended is 4 to 5. This ratio has an advantage of optimal interval between stitches and distance from wound edge (> 2 cm.).

The rate of incisional hernia was also high, 17% for overweight patients compared to 6% for non overweight patients. There was no significant difference between emergency and elective operation in the development of incisional hernia.

Israelsson [95] studied 1013 patients on closure of laparotomy wounds by a continuous technique, monofilament, mass closure while comparing between junior surgeons (10 years or less) and senior surgeons (more than 10 years) and found that there was no difference in the mean rate of wound infection (10%) and incisional hernia (15%) between the two groups. The rate of incisional hernia was high, 22% in those closed by suture length : wound length ratio of less than 4 compared to 9% for those sutured by a suture length : wound length ratio of 4 or more regardless of seniority.

Senbanjo and Ajayi [96] when evaluating 8632 laparotomies, found that the incidence of abdominal wound dehiscence was 2.5%. Wound dehiscence was most common in contaminated wounds (19%), prolonged duration of hospitalization (35 days), and carried a mortality of 7%. Richards et al [97] compared a continuous with an interrupted technique for closing 571 abdominal incisions for clean, clean-contaminated, and contaminated wounds and found that, there was no statistical difference in the rate of wound dehiscence or ventral hernias whether midline or oblique incision, continuous or interrupted closure.

It was concluded that dehiscence was more likely related to improper surgical technique than to the method of closure. Continuous technique took shorter time, 20 minutes compared to 40 minutes for interrupted closure.

Israelsson and Johnsson [98] studied the effect of body mass index (BMI) on the healing of midline laparotomy wounds with a continous technique on 1023 patients and found that being overweight (BMI>25) was not associated with a higher rate of wound infection or incisional hernia if the suture length : wound length ratio was 4.0 to 4.9.

Ellis and Heddle [99] on laparotomy wound closure found that closure of peritoneum as a separate layer appears to play no significant role in the healing of the laparotomy wound.

Israelsson and Johnsson [100] studied the role of suture technique in closure of midline laparotomy incisions with polydioxanone (PDS) and nylon and found that it is safe with either suture and incisional hernia is associated more with suture technique than with the material used.

Mingol et al [101] determined the incidence of incisional hernia following emergency abdominal surgery and found that the rate of incisional hernia could be reduced with proper attention to the suture technique which includes mass and continuous suture, better preparation of the operative field and maintainance of sterility throughout the procedure.

Shittu et al [83] found that mass-closure technique can be used on all high risk abdominal wounds

1.2.3 PERIOPERATIVE ANTIBIOTIC PROPHYLAXIS

Antibiotic prophylaxis is any antimicrobial given with the intention of preventing infection associated with an operation in the absence of infection at the time of operation [102]. Peuteck et al [103] and Osmon [104] recommended that antibiotic prophylaxis should be regularly available, provide adequate protection against presumptive micro-organisms, low toxicity, minimal side effects, low cost and short course of 12 to 48 hours. Prophylactic antibiotic should be administered intravenously [105].

(i) Timing of antibiotic prophylaxis

Polk [106] showed that antibiotics given before or simultaneously with a local wound contamination were highly effective, as if bacteria had been autoclaved. By contrast, antibiotics given as late as four hours after microbes have been inoculated, proved virtually worthless and promote emergence of resistant forms.

Classen et al [107] studied the impact of timing of antibiotic prophylaxis on surgical wound infection and found that if it was given 2 to 24 hours

preoperatively, the rate of surgical wound infection was 3.8% compared to 0.6% ($p<0.001$) if it was given less than 2 hours preoperatively. If it was given 3 hours postoperatively, surgical wound infection was 1.4% ($P=0.11$) compared to 3.3% ($P=0.8$) if it was given 3 to 24 hours postoperatively.

DiPiro et al [108] assessed intra-operative serum and tissue activity of cefoxitin and found that serum levels of cefoxitin at the time of incision was 99% if it was given at the induction of anaesthesia and this reduced to 22% two hours later. Lizáu-Garcia et al [109] did a prospective study on risk factors for surgical wound infection and found that administration of antimicrobial prophylaxis 2 hours or more before operation increases the risk of surgical wound infection by a factor of 5.3 compared to antibiotics closer to start of operation.

Another study by Wong-Beringer et al [110] on elective colorectal surgery using cefmetazole 2 gm intravenously either immediately prior to incision or 15-60 minutes prior to incision found that levels above Minimal Inhibitory Concentration(MIC)-90 of the common pathogens were sustained throughout the surgical procedure in both groups.

(ii) Antibiotic prophylaxis in abdominal surgery

Antibiotic prophylaxis is indicated in high-risk clean operations, clean–contaminated and contaminated wounds [20,105,110,111]. The antibiotics

could be applied locally, that is directly to the wound and into the peritoneal cavity or systemically.

Ghisotti et al [112] evaluated the effect of topical applications of lincomycin and gentamicin on 463 general surgery patients and found that the incidence of wound infection was significantly reduced compared to untreated control group. Sindelar and Mason [113] evaluated 500 patients following general surgical procedures and found that those wounds irrigated with povidone-iodine before closure had low infection rate, 2.9% compared to 15.1% for those irrigated with normal saline (control), $P<0.001$.

However, Molloy and Brady [114] determined the influence of povidone-iodine on wound healing of the open wound and found that there was an early effect on healing in wound dressed with saline and prolonged impairment of healing in povidone–iodine wounds. Also, Cruse [115] found that irrigation of serous cavity with antibiotic solution in 1535 patients did not make any difference in the rate of wound sepsis from a control group.

Pellock [116] randomized 405 patients following emergency or elective abdominal operations to receive a single dose of cephaloridine, 1 gm either injected intravenously at the start of operations or instilled into

incision at the end of operations and found that there was no significant difference in the rate of wound sepsis between the two groups.

Rutten and Nijhuis [117] evaluated 221 patients for colorectal surgery and found that the patients who received systemic gentamicin and metronidazole had a low wound infection rate of 5.6% versus 18.4% for those who had local application of gentamicin, $P<0.01$. Another study by Saven et al [118] evaluated 542 patients for emergency and elective abdominal operations and found that, there was a significant reduction of wound infection rate in the group that received intravenous 1 gm of latamoxef (moxalactam) at induction of anaesthesia than the group that had tetracycline peritoneal and wound lavage (8% versus 16.4%, $P= 0.012$). It was concluded that systemic antibiotic is more effective than lavage antibiotic after clean-contaminated and contaminated abdominal operations in reduction of wound infection rate.

On evaluating systemic prophylactic antibiotic regimens used, Xavier et al [102] found that, cephalosporins accounted for 77%. Recommended prophylactic antibiotic for gastroduodenal operations should be able to protect against *gram-positive cocci*, enteric *gram-negative bacilli* while for colorectal operations it should be able to protect against enteric *gram-negative bacilli* and *anaerobes* (Appendix III).

Lewis et al [119] classified biliary operations into low and high risk types. Low risk group includes those patients for simple cholecystectomy

among which 10% had positive bile cultures compared to 50% high risk group (acute cholecystitis, obstructive jaundice or choledochal stones). On randomizing the high risk group, it was found that the patients who received preoperative cefazolin sodium 2gm had low wound infection rate 4.7% versus 25% for those who had no preoperative antibiotic.

Chandrasheknar et al [120] randomized 177 patients for elective cholecystectomy and found that there was a significant reduction in wound infection rate among the patients who received preoperative antibiotic 3% versus 23% for those who received no preoperative antibiotic. Another study by Reiss et al [121] on 231 biliary operations (high risk), it was found that the rate of wound infection was significantly lower in the group that received preoperative antibiotic than the group that had no prophylactic antibiotic (3.5% versus 12.5%).

Several studies have been done and revealed that a single dose of prophylactic antibiotic had similar antimicrobial effect as multiple doses. Kager et al [122] compared the effectiveness of a single dose and three doses of latamoxef® (moxalactam) on colonic microflora following colorectal operation. It was found that there was a significant reduction of aerobic and anaerobic bacteria during the prophylaxis period in both groups. There was no difference between the patients receiving single dose of latamoxef and those receiving three doses.

Hall et al [123] compared the efficacy of a single dose of 1gm intravenous moxalactam with an extended course of 1gm intravenous moxalactam for 8 doses for 48 hours. The results showed that there was no significant difference between the two groups in the rate of wound infection (5.4% versus 6.1%).

Rowland et al [124] found that using single dose of intraoperative gentamicin sulphate and clindamycin phosphate, reduced surgical wound infection from 32.3% to 10.4%. McArdle et al [87] on evaluating prophylaxis in colorectal surgery found that cover for 3 days was no better than single day.

However, for a patient undergoing colorectal operations preoperative bowel preparation with oral neomycin and erythromycin or systemic antibiotics is recommended [125]. Coppa et al [125] found a significant decrease in wound infection in patients who received intravenous cefoxitin in conjunction with standard bowel preparation. Additional doses of prophylactic antibiotics have been recommended for operation which exceed 2 to 4 hours duration [105].

Infection is a major complication in patients with penetrating abdominal trauma. High risk factors include haemorrhagic shock, blood transfusion which causes immunosuppresion, and bowel injury [126].

Studies have been done on the role of prophylactic antibiotics following penetrating abdominal trauma and found that, a 24-hours course has similar effect as prolonged five-days course in preventing intra-abdominal and wound sepsis. Kirton et al [127] compared the safety and therapeutic efficacy of a 24-hours versus 5-day course of 3 gm intravenous ampicillin/salbactum given 8-hourly for the prevention of postoperative infections in 317 high risk patients sustaining hollow viscus injury (51% had colon injury). Results showed that the surgical wound infection was 10% and non-surgical wound infection was 11% in 24-hour group versus 8% and 20% respectively in the 5-day group. This difference was not significant, P= 0.16. It was concluded that high risk patients with colon or other hollow viscus injury have no greater risk for surgical wound infection or non surgical wound infection when treated with only a 24-hours course of broad-spectrum antibiotic.

Bozorgzadeh et al [126] randomized 300 patients following abdominal trauma to receive cefoxitin for 24-hours and 5-day course in the prevention of wound infection and found that, wound infection rate in 24-hours group was 28% compared to 23% in 5-day group. This difference was not significant and it was concluded that a duration of 24-hours of antibiotic was as effective as 5-day course in the prevention of infection following severe abdominal injury.

Cornwell et al [128] evaluated the effect of varying durations of antibiotic prophylaxis in trauma patients with multiple risk factors including full-thickness colon injury, more than four hours from injury to operation. Patients were randomized to receive a short course of 24 hours of 2 gm intravenous cefoxitin 6-hourly and a 5-day course of 2 gm intravenous cefoxitin 6-hourly. Results showed that 43% of all patients had colon resection, intra-abdominal infection rate was 19% and wound infection rate was 45% in short course group compared to 38% and 25% respectively in the long course. Statistically, the differences were not significant. Similar results were obtained by Fabian et al [129] when they randomized 515 patients with penetrating abdominal injury to receive cefoxitin or cefotetan for 24-hour and 5 days. The rate of intra-abdominal sepsis was 8% for single day treatment versus 10% for 5-day treatment. It was concluded that regardless of contamination and degree of injury, 24-hour antibiotic therapy is satisfactory for all penetrating abdominal trauma. Saadia and Lipman [130] in the forum for consensus for the duration of antibiotic following contaminated abdominal operations, such as traumatic bowel or perforated peptic ulcer recommended a single-dose preoperatively for early contamination (less than 12 to 24 hours).

However, Demetriades et al [131], when they randomized 123 patients with penetrating abdominal injuries to receive ceftriaxone or cefoxitin, an extended course to 48-hours was recommended in the presence of colonic injury. Also, Hirshberg and Mattox [132] recommended postoperative antibiotics should be reserved for late (more than 12-hours) operations following enteric perforations.

Ceftriaxone sodium (Powercef®) is a third generation semi-synthetic cephalosporin with a long *half-life* that has resulted in a recommended once daily administration schedule. Its MIC persists for 24 hours and this forms the basis of repeating the dose after 24 hours. It is effective against both gram-negative and gram-positive micro-organisms as well as anaerobes, mainly *Bacteroides fragilis* [133].

According to a study by Wayi [134], the sensitivity of Klebsiella species to ceftriaxone was 93.3% while that to gentamicin was 64.7% and the susceptibility of Pseudomonas species was 100% with ceftriaxone compared to 75% with gentamicin.

2. CHAPTER TWO

2.1 STATEMENT OF THE PROBLEM

Laparotomy wounds following clean-contaminated and contaminated operations have high risk of surgical wound infection, 10% and 20% respectively. These rates will be higher if prophylactic antibiotic is not given. At the Muhimbili National Hospital some surgeons close these wounds primarily while others leave them open to heal by second intention or third intention.

A mini-survey was conducted to determine the prevalence of clean-contaminated and contaminated wounds and their complications following laparotomy in the surgical department, Muhimbili National Hospital, covering a period of one year from June 1999 to May 2000.

Sample size was 74 patients and the specific objectives were to determine the rate of wound infection, hospital stay, and development of incisional hernia.

In this study, the following findings were noted; emergency operations accounted for 26% of all major operations. The commonest causes of clean contaminated and contaminated laparotomy wounds included traumatic bowel perforation (38 patients), sigmoid volvulus with or without gangrene accompanied by resection and colostomy (15 patients) and strangulated inguinal herniae (13 patients). Among these 66

patients, 24% had their wounds left open to heal by second or third intention, or had delayed primary closure compared to 76% whose wounds were closed primarily. Prophylactic antibiotics were given to all patients.

The rate of wound infection was 30% in those patients who had their wounds closed primarily compared to 5% for those who had their wounds left open. These rates were comparable to other studies [14,16]. The average hospital stay for those who had open wound management was 12.6 days compared to 6.8 days following primary closure. One patient among those who had their wounds closed primarily developed incisional hernia.

The commonest complications of laparotomy wounds include wound infection, dehiscence, prolonged hospital stay, incisional hernia and these lead to increased treatment costs.

No study has been done at our center to determine the complication rates of primary skin closure in clean-contaminated and contaminated laparotomy wounds versus leaving the wound open.

2.2 RATIONALE OF THE STUDY

With the improvement in surgical techniques, availability of new, broad-spectrum perioperative antibiotics, primary skin closure of contaminated wounds following laparotomy can be encouraged. Some studies show that, not all contaminated wounds become infected, relatively few do [135].

Primary skin closure of contaminated wounds following laparotomy if proved to be superior to leaving wounds open, will have the following advantages: cost-effectiveness both to the patients and the health care system, less trauma to the patients for second surgery for wound closure, short hospital stay and avoidance of repeated dressings.

Due to the above facts, it is justified to carry out a study at this center to compare the complication rates of primary skin closure for clean-contaminated and contaminated wounds following laparotomy and leaving wounds open.

3. CHAPTER THREE

3.0 OBJECTIVES OF THE STUDY

3.1 Broad Objective

To compare the complication rates of primarily closing the wound and leaving the wound open in clean-contaminated and contaminated laparotomy wounds.

3.2 Specific Objectives

(i) To determine the proportion of patients exhibiting pus discharge and wound dehiscence within four weeks of the time of laparotomy.

(ii) To determine the total duration the patient requires wound dressing following laparotomy.

(iii) To determine the time required to declare the wound healed from the time of laparotomy.

(iv) To determine the influence of wound healing on mortality.

(v) To determine the proportion of patients who develop incisional hernia within six months from operation.

4. CHAPTER FOUR

4.0 METHODOLOGY

4.1 STUDY DESIGN

This was a randomized clinical trial to compare the complication rates in clean-contaminated and contaminated laparotomy wounds between those primarily closed and those left open.

4.2 STUDY PERIOD

The study covered nine months duration, from January 2001 up to September 2001. This means that those patients recruited in the last six months could not be followed up to six months for assessment of incisional hernia.

During this period, the author was one of the team members in the management of these patients.

4.3. STUDY AREA

The study was done at Muhimbili National Hospital, Dar es Salaam, Tanzania. This is the largest consultant hospital in the country incooperating the Muhimbili University College of Health Sciences (MUCHS) of the University of Dar es Salaam.

This hospital receives the majority of the patients from within Dar-es-Salaam and nearby regions for both emergency and elective operations. A few patients are referred from upcountry and Zanzibar Islands. The hospital has a capacity of 1000 beds for inpatients and facilities for outpatient clinics for respective specialties.

The surgical department is one of the clinical departments in this hospital. The department includes both male and female adult wards (Ward 2,11,13,14 and 21) and General Paediatric Surgical ward. Adult wards are subdivided into three firms, each with a capacity of 46 male beds and 20 female beds. Paediatric surgical unit deals with patients aged 0 to 10 years whereby one month and below are admitted in ward 36 (neonatal ward) and above one month are admitted in ward 12 which has a capacity of 20 beds and 38 cots.
Ward 15 and 16 are reserved for surgical private patients for females and males respectively.

4.4. STUDY POPULATION

Inclusion criteria:

The studied population included all patients admitted in general surgical department, Muhimbili National Hospital, all age groups, both sexes who were assessed as having clean-contaminated and contaminated laparotomy wounds.

Exclusion criteria:

Those patients who did not receive peri-operative Ceftriaxone Sodium (Powercef ®) were excluded from the study.

All patients with jaundice, diabetes mellitus, advanced malignancy, patients on steroids and age above 65 years were excluded from the study too.

All patients with penetrating abdominal wounds who at laparotomy were found to have no hollow visceral perforation were excluded from the study. These patients had penetrating wounds separate from the surgical wound. Therefore, the risk of infection was to the penetrating wound rather than the laparotomy wound.

All patients who died before first assessment (fifth day of operation) were excluded from the study too.

4.5. SAMPLE SIZE

The sample was determined by the following statistical formula derived from Epiinfo 6 program.

$$n = \frac{(Z_\alpha + Z_\beta)^2 \times [P_1(1-P_1) + P_2(1-P_2)]}{(P_1-P_2)^2}$$

Where;

P_1 = Proportion infected among those with closed wounds of 30%

P_2 = Proportion infected among those with open wounds of 5%

Z_α = Percentage point corresponding to 5% level significance (1.96)

Z_β = Percentage point corresponding to 80% power (1.28)

n = Required sample size in each group.

$$= \frac{(1.96+1.28)^2 x [0.3(1-0.3)+0.05(1-0.05)]}{(0.3-0.05)^2}$$

= 43

From the above formula, the sample size was estimated to be 43 x 2 = 86.

Sampling procedure was simple randomization, by alternating technique.

4.6 DATA COLLECTION AND MANAGEMENT

Questionnaire forms were used to enter the data.

Laboratory forms were used to record the results of haemogram and total white blood cell count for each patient.

Registrars and residents in the Department of Surgery as well as other members of staff were involved in this study in collaborating with the author.

Haemoglobin level and white blood cells count, for each patient, were determined by Cell-Dyn® 1200 System (Abbott Laboratories).

Approach for a typical case of intra-abdominal contamination included:

(i) Suction of contaminants

(ii) Definitive surgery with controlled haemostasis

(iii) Copious peritoneal lavage using warm normal saline

(iv) Deep abdominal wall (peritoneum and fascia) closure using non-absorbable, monofilament, number zero or number one sutures (in adult) and 2/0 in children, either interrupted or continuous, with security sutures. Needle entry was not less than one centimeter from the edge and sutures were made tension free.

(v) Superficial wound was irrigated with normal saline.

(vi) Finally, wound was closed primarily or left open according to randomization.

Wound dressing:

Wounds were dressed with a thin layer of wet gauze for open wounds and dry gauze for closed wounds.

Dressings were not changed unless it was found to be stained with bloody discharge or purulent discharge.

If no evidence of purulent discharge on the fifth day of laparotomy, then the wound was closed as delayed primary closure and the dressing was kept until the seventh day of suturing when the sutures were removed and wounds left undressed.

A wound with purulent discharge was cleansed and dressed with Eusol daily until it granulated well for secondary suturing.

Those wounds closed primarily with no evidence of infection noticed on seventh day following laparotomy, sutures were removed and wounds left undressed

Dressings were stopped on the day of suture removal.

Wound infection:

The wound was considered to be infected if there was pain accompanied by swelling, redness or purulent discharge from the wound whether closed or open.

Healing ridge:

This was assessed by palpating a thickening of about 0.5 cm on either side of the incision along the entire wound length during follow-up. For open wounds this thickening was palpated after wound closure. Any defect was considered as abscent healing ridge and when there is no defect it was considered as present healing ridge.

Wound dehiscence:

This was considered when there was a gaping of the surgical wound with or without evisceration of abdominal contents.

Incisional hernia:

This was considered present when there was a protrusion of the abdominal viscera through a defect in deep fascia at the surgical incision site.

4.7 PERIOPERATIVE ANTIBIOTIC

Each patient received Ceftriaxone Sodium (Powercef®) injection 1 gramme intravenously given at the time of induction of anaesthesia. The same dose was repeated in the same route after 24 hours. Children below 12 years of age received a dose of ceftriaxone sodium (Powercef®) 50mg/kg body weight and not more than 2 gram in a single dose.

4.8. FOLLOW UP

These patients were followed up by the author as follows; 5th day, 10th day, 28th day and six months including both inpatients as well as outpatients to assess any complication arising from, or related to the wound.

4.9 DATA ANALYSIS:

At the end of the study, all data and results obtained were analysed manually and using Epiinfo 6 computer program to determine if there are statistically significant differences between the two groups .

Chi-square (X^2) was used when comparing the proportions of the two groups.

"t"-test was used when comparing the mean value of the two groups.

"Fisher" test was used when comparing small numbers.

5.0 ETHICAL ISSUES:

Ethical clearance for the study was granted by the Research Ethical Committee of the MUCHS.

In this study, half of the wounds were left open by randomization. According to the standard of surgery it is recommended to leave open all clean-contaminated and contaminated wounds due to high risk of infection. Delayed primary closure is normally done on the fifth day of laparotomy if there is no evidence of infection (healing by first intention). Secondary closure for those infected wounds is normally considered when there is a good granulation tissue (healing by third intention). Some wounds may heal with second intention (by granulation from the base upwards without suturing).

The other group includes patients whose wounds were closed primarily by randomization. Recent advances in surgery have shown that wound infection rate in closed wounds of clean-contaminated and contaminated laparotomy can be reduced by good surgical techniques with perioperative antibiotics.

Following abdominal operations, perioperative antibiotics have been advised to augment good surgical techniques in order to reduce the rate of wound infection. Perioperative antibiotics reduce the risk of surgical wound infection significantly such that it avoids the need for five to

seven days course. In this study all patients from both groups received two doses of Ceftriaxone Sodium (Powercef®). The first dose was given free of charge to all patients. The second dose was given free of charge to those patients who could not afford to buy within 24 hours following laparotomy. Two doses of third generation Cephalosporin are advised in colorectal operations and operations lasting longer than four hours. This antibiotic was donated by Salama Pharmaceuticals Limited.

Patients were not charged laboratory fees as these were taken care of by the study protocol.

6. NULL HYPOTHESIS:

Null hypothesis states that, there is no significant difference in the complication rate in clean-contaminated and contaminated laparotomy wounds whether closed primarily or left open.

5. CHAPTER FIVE

5.1 RESULTS

5.1.1 PATIENT POPULATION

During the study period, January 1st 2001 to September 30th 2001 a total of ninety six patients with clean-contaminated and contaminated abdominal wounds were enrolled into the study. These patients were admitted in the Department of General Surgery which includes Paediatric Surgery.

Among these patients ninety (93.7%) met the inclusion criteria for the study. These patients included those operated upon on emergency basis (50 patients) and scheduled operation (40 patients). Six patients were excluded from the study as they died before first assessment due to intestinal obstruction. The causes for intestinal obstruction were; sigmoid volvulus, three patients, ileocaecal tumour, two patients and gangrenous ileoileal intussusception , one patient.

In this study, follow up on fifth and tenth day of laparotomy had 100% coverage. On twenty eighth day of laparotomy coverage was 97.8% and only 36.7% of patients could be followed up to sixth month.

5.1.2 DEMOGRAPHIC CHARACTERISTICS OF PATIENTS:

(i) AGE AND SEX

The patients' median age was 32.0 with a standard deviation of 16.7. The peak age was 20-40 which accounted for 50% of the studied patients. The extremes of age had a minority of patients whereby; twenty years of age or below accounted for 14.5% and above sixty years of age accounted for 13.3% of the studied population.

In this study, were sixty seven males (74%) and were twenty three females (25.6%) making a male to female ratio of 2.9 to 1.

Table 1 summarizes these results.

TABLE 1: DISTRIBUTION OF PATIENTS BY AGE AND SEX

Age group (Yrs)	Sex		Total (%)
	Male	Female	
≤20	9	4	13 (14.5)
21 - 40	36	9	45 (50.0)
41 - 60	16	4	20 (22.2)
61 - 65	6	6	12 (13.3)
TOTAL	67 (74.4%)	23 (25.6%)	90 (100%)

(ii) PREOPERATIVE DIAGNOSES

The commonest clinical conditions which led to clean-contaminated and contaminated laparotomy wounds included; intestinal obstruction (eighteen patients), penetrating abdominal wounds (seventeen patients), obstructed hernia (nine patients) and carcinoma of urinary bladder (seven patients). Various other conditions were responsible for the remaining 39 patients.

Table 2 summarizes the above information.

Table 2 : **PREOPERATIVE DIAGNOSES OF THE PATIENTS**

Serial no.	Diagnosis	Frequency	%
1	Intestinal obstruction	18	20.0
2	Penetrating abdominal wounds	17	18.9
3	Obstructed hernia	9	10.0
4	Carcinoma of urinary bladder	7	7.8
5	Calculous cholecystitis	4	4.4
6	Terminal colostomy	4	4.4
7	Ectopia vesicae	3	3.3
8	Carcinoma of stomach	3	3.3
9	Reduced gangrenous hernia	3	3.3

10	Anorectal carcinoma	3	3.3
11	Gastric outlet obstruction	2	2.2
12	Imperforate anus	2	2.2
13	Perforated typhoid ulcer	2	2.2
14	Postoperative faecal fistula*	2	2.2
15	Ectopic gestation	1	1.1
16	Intra-abdominal cyst	1	1.1
17	Left hydronephrosis	1	1.1
18	Pancreatic pseudocyst	1	1.1
20	Redundant sigmoid colon	1	1.1
21	Renal carcinoma	1	1.1
22	Blunt abdominal injury	1	1.1
23	Ureteric injury post VVF repair	1	1.1
24	Benign prostatic hyperplasia	1	1.1
25	Gastric diverticulum	1	1.1
26	Recurrent leiomyosarcoma of colon	1	1.1
TOTAL		90	100.0

*This patient underwent re-laparotomy with bowel resection.

(iii) INTRAOPERATIVE DIAGNOSES

During laparotomy a final diagnosis of patients with intestinal obstruction was obtained as follows; intestinal obstruction due to sigmoid volvulus thirteen patients, obstructed hernia nine patients, constricting bands/adhesions four patients and ileo-ileal intussusception two patients.

One patient who was clinically (preoperatively) thought to have ectopic gestation was ultimately found to have a constricting band involving a loop of ileum with gangrene.

Table 3 summarizes the above information.

TABLE 3: THE INTRAOPERATIVE DIAGNOSIS OF INTESTINAL OBSTRUCTION

Cause of obstruction	Frequency	%
1. Sigmoid volvulus	13	47.0
2.Obstructed hernia	9	32.0
3. Constricted bands/adhesions	4	14.0
4. Intussusceptions	2	7.0
TOTAL	28	100.0

Among twelve patients who had obstructed herniae, eight had gangrenous inguinal herniae which were not possible to manage through inguinal incision but through laparotomy incision. Three patients had spontaneous reduction of inguinal hernia with features of peritonism and therefore, laparotomy was done. One patient had strangulated incisional hernia.

Of seventeen patients who had penetrating abdominal wounds, seven patients had perforated jejunum, five patients had perforated ileum, one patient had perforated stomach, one had perforated ileum and colon, one had perforated sigmoid colon, one had perforated duodenum and stomach and one had perforated stomach and diaphragm.

Table 4 summarizes this information.

TABLE IV: THE DISTRIBUTION OF ANATOMICAL SITES IN PENETRATING ABDOMINAL WOUNDS

Anatomical site perforated	Frequency	%
Jejunum	7	35
Ileum	6	30
Stomach	3	15
Colon	2	10
Diaphragm	1	5
Duodenum	1	5
TOTAL	20	100

(iv) WOUND MANAGEMENT

In the final wound management, patients were simply randomized either for primary skin closure or open method. Forty seven patients had their wounds closed primarily and forty three patients had their wounds left open. Among those who had their wounds left open, thirty two had delayed primary closure done on the fourth day and eleven patients had secondary suturing.

Table 5 summarizes the above information.

TABLE 5: DISTRIBUTION OF PATIENTS ACCORDING TO METHOD OF WOUND MANAGEMENT

Type of wound management		Frequency	%
Primary skin closure		47	52.2
Open wounds	Delayed Primary closure	32	35.6
	Secondary closure	11	13.2
TOTAL		90	100

(v) WOUND DRESSING

While comparing the total duration required for wound dressing it was found that, the overall mean was thirteen days. The mean duration for dressing the primarily closed wounds was eleven days compared to sixteen days for those who had open wounds .

Table 6 summarizes this information.

TABLE 6: TYPE OF WOUND TREATMENT AND MEAN DURATION OF WOUND DRESSING

Type of wound treatment	Mean duration of dressing (days)
Primary skin closure	11 (SD = 4.5)
Open wounds	16 (SD = 6.7)

p = 0.0002 t = 3.8 d.f=1

SD - standard deviation

d.f-degree of freedom

(vi) DEVELOPMENT OF HEALING RIDGE

While assessing development of a healing ridge as an indicator of wound healing it was found that, eighty two patients (92%) developed healing ridge and eight patients (8%) had no healing ridge. Among those who developed a healing ridge, sixty patients (73.2%) developed the ridge within two weeks of laparotomy, nineteen patients (23.2%) developed the ridge within one week of laparotomy and three patients (3.7%) within three weeks of laparotomy.

Forty four out of forty seven (93.6%) patients who had their wounds closed primarily, developed the healing ridge compared to thirty eight (88.4%) of those patients who had their wounds left open.

Table 7 summarizes the above information.

TABLE 7: DISTRIBUTION OF PATIENTS ACCORDING TO WOUND TREATMENT AND DEVELOPMENT OF HEALING RIDGE

Type of wound treatment	Healing ridge	No healing ridge	Total
Primary skin closure	44 (93.6%)	3 (6.4%)	47(100)
Open wounds	38 (88.4%)	5 (11.6%)	43(100)
TOTAL	82 (92.0%)	8 (8.0%)	90(100)

Yates corrected $X^2=0.25$ p=0.6 d.f =1

(vii) WOUND COMPLICATION

FIFTH DAY POST LAPAROTOMY:

During follow up it was found that on the fifth day post laparotomy seventy six patients (84.4%) had no pus discharge or wound

dehiscence while fourteen patients (15.6%) developed pus discharge.

Among those who had their wounds closed primarily, forty six (97.9%) had no complication, while one patient (2.1%) developed pus discharge. Among those who had open wounds thirty patients (69.8%) had no complications compared to thirteen patients (30.2%) who developed pus discharge.

Table 8 summarizes the above information.

TABLE 8: DISTRIBUTION OF PATIENTS BY WOUND TREATMENT AND PUS DISCHARGE ON FIFTH DAY POST LAPAROTOMY

Type of wound treatment	Complication		Total
	No complication	Pus discharge	
Primary skin closure	46 (97.1%)	1 (2.1%)	47 (100)
Open wounds	30 (69.8%)	13 (30.2%)	43 (100)
TOTAL	76 (84.4%)	14 (15.6%)	90 (100)

$p = 0.0002$ $X^2=13.5$ d.f=1

TENTH DAY POST LAPAROTOMY:

During follow up, on the tenth day of laparotomy, the overall wound infection rate was 14.4%, and one patient (1.2%) developed wound dehiscence. While comparing complications on tenth day post laparotomy it was found that among those patients whose wounds were closed primarily, forty five (95.8%) had no complication, one (2.1%) had pus discharge and one (2.1%) developed wound dehiscence while of those who had open wounds, thirty one (72.1%) had no complications, twelve (27.9%) had pus discharge and none developed wound dehiscence. See table 9.

TABLE 9: DISTRIBUTION OF PATIENTS BY WOUND TREATMENT AND DEVELOPMENT OF PUS DISCHARGE AND WOUND DEHISCENCE ON TENTH DAY POST LAPAROTOMY

Type of wound treatment	Complications			TOTAL
	No complication	Pus discharge*	Wound dehiscence+	
Primary skin closure	45 (95.8%)	1 (2.1%)	1 (2.1%)	47
Open wounds	31 (72.1%)	12 (27.9%)	0 (0.0%)	43
TOTAL	76 (84.4%)	13 (14.4%)	1 (1.1%)	90

*p = 0.002 +p > 0.05

TWENTY-EIGHTH DAY POST LAPAROTOMY:

During follow up on twenty eighth day of laparotomy eighty one patients (92%) had no complication while overall, seven patients(8%) had pus discharge. On comparing the two groups, among the patients who had primary skin closure, two patients (4.3%) had pus discharge while those with open wounds, five (11.9%) had pus discharge.

(Yates corrected X^2=0.84 d.f=1 p=0.4)

Two patients (2.2%), one from each group died.

ONE HUNDRED AND EIGHTY DAYS POST LAPAROTOMY:

At the end of the study only thirty nine patients were six months or more from the time of laparotomy. Among these patients, six (15%) could not be followed up due to the following reasons; one patient died, one patient was from upcountry and four patients did not turn up for unknown reason.

Among thirty three patients who were followed up, only one (3%) developed incisional hernia . She belonged to the open group.

It was difficult to compare the level of significance of incisional hernia between the two groups due to small number of patients who were followed up to six months after laparotomy.

(viii) HAEMOGLOBIN LEVEL

The haemoglobin level in the studied patients ranged from 5.5gm/dl to 15.2gm/dl with an average of 10.2gm/dl. On comparing the two groups, it was found that the average haemoglobin level for those patients who had primary skin closure was 10.3gm/dl compared to 10.2gm/dl for those who had open wounds.

(p=0.7)

(ix) WHITE BLOOD CELL COUNT LEVEL

For the studied population, it was found that the average white blood cells count was 9 x 10^3 cells/mm^3 on day of first assessment. The average white blood cell count for those patients who had primary skin closure was 9.7 x 10^3 cells/mm^3 compared to 8.7 x 10^3 cells/mm^3 for those who had open wounds.

(p=0.1)

(x) DEATHS

During follow up, two patients died, one had primary skin closure and the other had delayed primary closure. Both deaths were not related to wound complications.

5.2 DISCUSSION:

The causes of intestinal obstructions were : sigmoid volvulus, obstructed hernia, constricting bands/adhesions and intussusceptions (Table 3). The commonest injured anatomical viscera following penetrating abdominal wounds are jejunum(35%) and ileum(30%), but any viscus might be injured either singly or in combination (Table 4). These data are comparable with the study done by Bozorgzadeh et al [126] who found that patients with abdominal stab wounds have approximately 29% risk of small bowel injury and 18% colon injury, gun shot wounds have 45% risk of small bowel injury and 38% risk of colon injury.

5.2.1 WOUND DRESSING:

In the current study, it was found that it takes a relatively longer period to dress those wounds which were left open than those which were closed primarily. This difference is statistically significant ($p = 0.0002$). Wound dressing changes were done both for inpatients and outpatients during follow up.

5.2.2 DEVELOPMENT OF HEALING RIDGE:

During wound healing from laparotomy there is development of healing ridge along the entire wound from seven to nine days of laparotomy [24]. In this study, 73.2% of patients developed healing ridge in the second week of laparotomy. Statistically, there was no significant difference in the development of healing ridge between the primary closure and open wounds ($p = 0.6$). Therefore, the development of healing ridge is not influenced by wound management.

From this study, the failure to develop the healing ridge was not correlated with wound dehiscence or incisional hernia. This suggested that absence of healing ridge is not necessarily accompanied by wound dehiscence or incisional hernia.

5.2.3 WOUND INFECTION

(i) FIFTH DAY POST LAPAROTOMY:

The rate of wound infection was 15.6% in this study. This data was comparable with other studies [60, 63, 64] for clean-contaminated and contaminated wounds (10% to 20%) and could be explained by the adherence to standard surgical technique as well as use of antimicrobial surgical prophylaxis (Powercef®). In this study, the rate of wound

infection was higher for those wounds which were left open (30.2%) compared to those closed primarily (2.1%). This difference was statistically significant (p = 0.0002) and is contrary to what was expected according to other studies [12,14, 16] and pilot study.

Paul et al [12] in 1976 found the rate of wound infection in primary skin closure of 11.8% compared to 5.8% in delayed primary closure.

Meissener and Meiser [14], found the rate of wound infection of 39% in primary skin closure compared to none in open wound treatment.

Smilanich et al [16], found the rate of wound infection of 27% in wounds closed primarily compared to 3% for delayed primary closure. In the pilot study, only 24% of the patients had their wounds left open and most of these wounds were managed in one firm which could explain the bias.

Higher infection rate for open wounds than closed wounds (30.2% versus 2.1%) in this study could be explained by high risk of wound contamination from the patients' skin and environmental sources during frequent dressing changes of the open wounds.

In this study the following factors were noted: On the day of the Major Ward Rounds all wounds whether infected or not were undressed for several hours in order to be inspected by doctors. Occasionally the wards were overcrowded especially following a day of admission.

Overcrowding caused postoperative patients to be placed nearby or between patients with septic conditions. It also made it difficult to maintain proper hygienic conditions in the Wards. These factors seem to predispose open wounds to higher risk of infection than closed wounds. Forrester [24] found that undisturbed open wounds heal better and dressings may therefore impair the healing of open wounds by damaging the delicate new cells and capillaries on the wound surface. Therefore unless infected, wound dressings should not be changed. Also, another study revealed that wounds that are left open tend to become dry and covered by a hard crust which delays healing [21].

According to Wayi[134] in a local study at Muhimbili National Hospital the clinical infection rate of clean operations was 12.9%. The commonest organisms in his study included both gram positive and gram negative organisms (Staphylococcus aureus, Klebsiella species, Escherichia coli, Pseudomonas species, Proteus species, and Streptococcus. This also suggests environmental factors as well as patients' skin as source of infection.

(ii) TENTH DAY POST LAPAROTOMY:

Still up to tenth day post laparotomy, wound infection was a major complication (14.4%) and one patient (1.2%) developed wound dehiscence. Still a higher infection rate occurred in those wounds which were left open than those which were closed primarily (27.9% against 2.1%). This difference was statistically significant (p=0.002).

In this study, development of wound dehiscence was not a major problem (1.2%). This shows that, most of the wound infection was superficial rather than deep infection involving deep fascia.
The patient who had wound dehiscence had laparotomy for total cystectomy with urinary diversion (ureterosigmoidostomy) and the wound was closed primarily. This patient developed anastomotic leakage then wound sepsis which was followed by dehiscence. This patient had to undergo re-laparotomy for closure of wound.
Intraabdominal sepsis contributed to wound dehiscence.
Jurkovich and Carrico [136] found that the causes of abdominal wound dehiscence includes:

(i) Imperfect technical closure

(ii) Increased intra-abdominal pressure from bowel distension, ascites, coughing, vomiting or straining

(iii) Haematoma with or without infection

(iv) Infection and

(v) Metabolic diseases such as: diabetes mellitus, uraemia, Cushing disease and malignancy.

Senbanjo and Ajayi [96] found the rate of abdominal wound dehiscence of 2.5% with mortality rate of 7% while Fleischer et al [137], found that the rate of abdominal wound dehiscence was 1% with a mortality rate of 15% to 45%. The predisposing factors were local wound infection and poor technique.

Bucknall [138] found that the rate of wound dehiscence was 1.7% and this was associated with wound infection. Mass-closure reduced the dehiscence rate from 3.8% to 0.76%. A monofilament non-absorbable suture was concluded to be most suitable suture for closing contaminated and infected abdominal wounds. Bucknall et al [139] in 1982, found that mass-closure technique reduced the incidence of wound dehiscence from 3% to 0.95%.

Gislason et al [140] found that the surgeon is a risk factor in wound complications following gastrointestinal operations. Several studies have been done on closure technique, incisions, and suture materials but the most important factor is the individual surgeon. Regular audit with feedback to individual surgeon is an important instrument for quality improvement.

(iii) TWENTY EIGHTH DAY POST LAPAROTOMY:

The overall infection rate was 8%, higher in those wounds left open than those closed primarily (11.9% versus 4.3%). Statistically this difference was not significant (p = 0.4). This shows that as time advances, that is, on/from twenty eighth day, there is no significant difference in wound infection rate between the two groups.

Two patients died, but the cause of their death was unrelated to wound complications. One of these two patients had purulent cystitis histologically with necrosis of the urinary bladder and died of cerebral vascular accident on eleventh day post laparotomy for partial cystectomy. The other patient died of septicaemia due to intraabdominal sepsis following laparotomy for perforated typhoid ulcer on the eighteeth day of laparotomy. This patient had a clean open wound which was closed on fifth day of laparotomy and healed well. He remained with a swinging pyrexia and deteriorating condition.

5.2.4 DEVELOPMENT OF INCISIONAL HERNIA

ONE HUNDRED AND EIGHTY DAYS POST LAPAROTOMY:

Among thirty three patients who completed six months post laparotomy and could be followed up, one patient among those closed primarily (3%) had incisional hernia. Fifty-one patients had not completed six months of laparotomy when the study ended, six patients could not be followed up.

In order to conclude on the incidence of incisional hernia a longer follow up and larger sample size will be needed. In this study it was difficult to comment on the development of incisional hernia due to small number of patients who were followed up to six months.

Incisional hernia has been found to be associated with wound infection and suture technique [76, 94, 95, 100,138,139]. Israelsson et al [76, 94, 95] found that the factors associated with incisional hernia included, wound infection (27% versus 9%), suture-length:wound-length ratio less than 4 or more than 5, overweight (BMI>25) and age 60 years or above. Buknall [138] and Buknall et al [139] found the same incidence of incisional hernia (7.4%) which was associated with wound infection.

5.3 CONCLUSION:

1. In this study, there was no major complication arising from clean-contaminated and contaminated laparotomy wounds apart from wound infection. The overall infection rate in this study was 15.6 % which was within the normal range of 10-17% . Wound dehiscence accounted for 1.1%

2. The rate of wound infection was higher in open wounds than in closed wounds contrary to what was expected. This was attributed to the contamination during dressing changes mainly from exogenous sources and patients' skin rather than intra-abdominal sources.

3. Open wounds require a longer duration of dressing than closed wounds. This implies more dressing changes during delayed primary closure or secondary suturing which is inconvinient to the patient as well as being an economical burden. The patient with open wound will require a second operation for wound closure either as delayed primary closure or secondary closure.

4. Development of a healing ridge does not depend on the type of wound management. In this study there was no wound dehiscence or incisional hernia which was attributed to absence of the healing ridge.

5. It was difficult to conclude on the development of incisional hernia in this study due to small number of patients who were followed up to six months of laparotomy.

5.4 RECOMMENDATIONS:

1. Clean- contaminated and contaminated laparotomy wounds can be closed primarily if no gross spillage is encountered during the operation and a patient receives antimicrobial surgical prophylaxis.

2. Surgical wound dressings should not be changed unless there is evidence of wound infection or on the fifth day of laparotomy for open wounds during delayed primary closure or during sutures removal.

3. There is a need to have a surveillance committee on wound infections in particular type of operations. The surveillance team must give feedback to the concerned surgeon who in turn must review the preventive measures.

4. Further studies need to be done to determine the risk factors for open wounds to develop infection, to compare effectiveness of different types of antibiotics and also to compare elective against emergency operations.

5.5 STUDY LIMITATIONS

1. The amount of funding (Tsh.600,000.00) allocated for the research is not sufficient especially when considering high laboratory costs and other materials. Such things as bacteriological aspect could have been studied in this research and two doses of perioperative antibiotic (Powercef®) could have been provided to all patients free of charge.

2. There was no constant availability of dressing materials due to frequent breakdown of the central sterilizing centre autoclave.

3. There was a shortage of nursing staffs in the department leading to a prolonged wound exposure before dressing.

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