A study to compare the efficacy of two suturing techniques in reducing the development of post-operative complications among patients with generalized peritonitis who underwent midline laparotomy

By

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A DISSERTATION SUBMITTED TO THE TAMIL NADU DR. M G R MEDICAL UNIVERSITY, CHENNAI, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF M S GENERAL SURGERY (BRANCH I)

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CHAPTER I

INTRODUCTION

The abdominal cavity has rightly been compared to Pandora's Box. Innumerable processes are simultaneously at work to maintain a physiological milieu compatible with life. Various extrinsic and intrinsic insults can lead to disease and affect normal functioning of abdominal organs. Many abdominal disease processes demand surgical correction in the form of a laparotomy. Even today, diagnostic surgical exploration is sometimes necessary.

Vertical midline incisions have long been popular. This is because of the ease and expediency with which they can be made and closed.[1] A midline approach provides access to all quadrants of the abdomen. It avoids devascularisation and denervation during incision or closure. The incision can be extended easily when necessary. The chief disadvantage of the midline incision is the common occurrence of wound disruption and incisional hernia.

Moynihan[2] in 1926 stated, "I do not think that, though much has been written thereon, it is yet adequately recognized that the steps in the making and in the repair of an abdominal wound are of the greatest importance." More than three-quarters of a century later, abdominal wound closure still remains a controversial subject, among even the most renowned surgeons. The present day incidence of wound dehiscence ranges from 1 to 6 percent while burst abdomen remains at 1-3 percent. The mortality associated with disruption may be as high as 35 to 40 percent.[3, 4, 5]

There are various factors that predispose an individual to these post-operative wound complications. These include a patient's demographic profile, co-morbid illness, lifestyle factors, and surgical technique. What does the surgeon have in his control to prevent these complications?

(1) Choice of suture material and (2) the technique of wound closure.

Surgery and sutures are inseparable. Down the ages, newer and more efficacious suture materials have been introduced. During the turn of the twentieth century, absorbable catgut suture was state of the art. It was phased out only when Goligher[6] decried its usage due to frequent wound dehiscence. Next began the era of non-absorbable suture materials, initially in the form of stainless steel and later on synthetic non-absorbable sutures with better handling characteristics and wound security. Within the last decade this trend of using non-absorbable sutures has changed, with numerous studies and meta-analyses advocating the use of slowly absorbable sutures. They claim comparable wound strength with significantly lower incidence of wound infection, suture sinus, and scar pain.[7,8, 9,10,11]

The currently accepted technique of abdominal fascial closure is the mass closure technique with a suture length-to-wound length ratio of greater than 4:1.[12] What is still disputed is the choice between continuous and interrupted techniques of closure. There are advantages and disadvantages of each technique. Numerous studies have been done to determine which is superior with conflicting results.

NEED FOR THE STUDY

Despite advances in surgical technique and materials, abdominal fascial closure has remained a procedure that often reflects a surgeon's preference with a reliance on anecdotal experience. The best abdominal closure technique should be fast, easy, and cost-effective, while preventing both early and late complications.

Several theoretical and practical facts have been described about operative site healing. They include the physiology of fascial healing, the physical properties of specific closure methods, the properties of the available suture materials, and patient-related risk factors. Yet the ideal technique, although suggested by surgical literature has not been uniformly accepted.[11] The efficacy of a particular technique may be measured by the incidence of early and late wound complications. Early complications include wound infection, wound dehiscence, and burst abdomen; whereas late complications include incisional hernia, suture sinus, and wound pain.

A sound suture technique should hold good in all circumstances, i.e., both in clean and contaminated wounds. Very few studies have compared the efficacy of suturing technique in contaminated wounds. There is no Indian data available on this subject. The Indian patient differs from his counterpart in developed countries in terms of nutritional status, financial capacity, and associated morbidity patterns.[13] Data collected from other

nations may not necessarily be applicable here. Hence, a contextualized approach to the problem is indicated.

RESEARCH STATEMENT

A prospective non-randomized study to compare the efficacy of two suturing techniques: continuous and interrupted (in current use) in reducing development of post-operative complications among patients with generalized peritonitis who underwent midline laparotomy while admitted in the General Surgical Units of Christian Medical College, Vellore.

OBJECTIVES OF THE STUDY

The purpose of the study includes the following:

1. To assess the incidence of post-operative complications among patients with generalized peritonitis undergoing midline laparotomy.
2. To determine the association between the suturing techniques and post-operative complications and to see if interrupted closure led to fewer post-operative complications.
3. To determine the association of the post-operative complications with the demographic and clinical variables.

OPERATIONAL DEFINITIONS

Generalized peritonitis: is defined as collection of pus or intestinal contents in more than one quadrant or compartment of the peritoneal cavity.

Suturing technique: is defined as the method and material used in the closure of the fascial layer.

Methods: (1) Interrupted technique

(2) Continuous technique

Material: No. 1 size polydioxanone suture

Post-operative complications: are defined as wound complications occurring following midline laparotomy for generalized peritonitis. They can be divided into early and late complications.

Early complications: are those wound complications that usually occur within 10 days following closure of a midline laparotomy wound. They include:

Wound infection: is defined as pus discharge at the wound site, which may or may not be confirmed by a bacteriological culture.

Wound dehiscence: is defined as post-operative wound separation that involves some but not all of the layers of the abdominal wall.

Burst abdomen: is defined as post-operative wound separation that involves all layers of the abdominal wall with protrusion of abdominal viscera through the wound.

Late complications: are those wound complications that usually occur a few months following closure of a midline laparotomy wound.

Incisional hernia: can be defined as a visible bulge when the patient stands up or coughs; together with a sharp-margined defect in the abdominal wall at the site of the scar.

Demographic variables: include the age and gender of the subjects.

Clinical variables: include duration of hospital stay, co-morbid illness, lifestyle factors, nutritional status, focus of insult, and need for intensive care and ventilation.

PROJECTED OUTCOME

The current practice for fascial closure of midline laparotomy incisions in the Department of General Surgery, Christian Medical College and Hospital, Vellore, has been to use monofilament, slowly absorbable sutures (No. 1 Polydioxanone) as a mass closure. The technique of closure has been variable. This study seeks to allocate patients into two groups: one, in which the continuous technique is used for the closure of the linea alba, and the other in which an interrupted technique is used. The study aspires to observe and record wound complications after midline laparotomy incisions in the hope of spurring renewed interest in abdominal closure, and possibly gathering evidence that warrants change in the current trend, or evidence encouraging the ongoing practice.

CHAPTER II

REVIEW OF LITERATURE

INTRODUCTION

Bigelow (1854), as cited by Murray and Blaisdell,[14] in his epic work 'Nature in Disease' defined the incised wound as a self-limited disease to which there is due a certain succession of processes to be completed in a certain time. During this time the process may vary with the constitution and condition of the patient and may tend to death or recovery, but which are not known to be shortened or greatly changed by medical treatment.

The above statement rings true even in this modern age! Although our understanding of the biologic process of wound healing has increased, it appears as if little of that knowledge has been transferred to the operating room. In fact, the incidence of abdominal fascial dehiscence has not diminished appreciably in the last century. This complication is still associated with a significant mortality rate, notwithstanding the associated morbidity, duration of hospital stay, and the associated financial implications.

The ideal method of abdominal wound closure has not yet been discovered. The ideal method should be technically so simple that the results are as good in the hands of the trainee as in those of the surgical master; it should be free from wound complications; it should be

comfortable to the patient; and it should leave a reasonably aesthetic scar.[15] Surgical tradition, prejudice, familiarity, and personal conviction tend to dictate surgical procedures rather than evidence-based medicine. Breaks from tradition in this area are quick to rouse skepticism in the surgical community. Thus, 'custom' wound closures are perpetuated.[16]

Promotion of safe and effective wound closures should be grounded on objective evidence reported by other surgeons. Thus a review of literature was done to address the above problem under the following headings:

- Surgical anatomy of the anterior abdominal wall
- Wound healing
- Factors influencing wound healing
- Generalized peritonitis and the contaminated wound
- Wound infection
- Wound dehiscence
- Burst abdomen
- Incisional hernia
- Suture sinus and post-operative wound pain
- Choice of suture material
- Technique of wound closure
    - Mass closure versus layered closure
    - Suture length-to-wound length ratio
    - Continuous versus interrupted technique

- Studies:

  Studies on choice of suture material with regard to wound complications

  Studies on choice of suture technique with regard to wound complications

SURGICAL ANATOMY OF THE ANTERIOR ABDOMINAL WALL

Omar M. Askar[17] in 1977 compared the functional role of the aponeuroses of the muscles of the anterior abdominal wall to that seen in the deep fascia of the leg. He concluded that the linea alba should no longer be regarded as the line of insertion of the abdominal muscles. It is likened to the area of decussation of the tendinous aponeurotic fibres of the muscular strata passing freely from one side to the other, for which the name 'midline aponeurotic area' was proposed. He proposed the 'triple pattern of decussation' of the anterior abdominal wall muscle, providing additional strength to the first line of defence against herniation.

The fact that the anterior abdominal wall aponeuroses are formed of fine tendons invested in loose areolar tissue indicates their free mobility over each other, which allows an appreciable degree of mobility in the resultant fabric, the aponeuroses. The oblique direction in which the aponeurotic fibres are placed in this fabric offers freedom for changes in both the longitudinal and transverse diameters.

The difference in the aponeurotic pattern above and below the umbilicus points to the difference in function of the two regions. Above the umbilicus, the pattern and shape of the aponeuroses fulfill the required expansile distensibility needed for respiration, simulating a parachute mechanism comparable with that of the diaphragm. Below the umbilicus, most of the muscular bundles as well as their aponeurotic fibres, being directed downwards and medially, simulate an elastic belly support.

Vertical midline incisions cutting through the linea alba have long been popular. This is because of the ease with which they can be made and closed. Devascularisation and denervation are avoided. A midline approach provides access to all quadrants of the abdomen. The incision can be extended easily when necessary.

The drawback of the midline incision is the common occurrence of wound disruption and incisional hernia. Korenkov et al[18] did cadavaric studies on the morphological types of linea alba and described a correlation between the thickness and density of fibres in the linea alba and its tensile strength. They noted that a combination of low density and thin fibres of linea alba are a predisposing factor for the development of incisional hernia.

The paramedian wound has the theoretic advantage of having two fascial layers buttressed by an intervening, well-vascularised layer of muscle. However, in most comparisons with midline wounds, paramedian wounds

have had a higher incidence of disruption and herniation. This clinical experience is substantiated by laboratory investigations, which routinely demonstrate greater suture holding strength and wound-bursting pressures for midline incisions than for paramedian incisions.[19]

Leaper et al[20] recorded the suture-holding strength of abdominal wall structures in cadavers and noted that holding strength of sutures placed 1 cm from the fascial edge was 7.16 kg compared to 3.93 kg for sutures placed < 0.5 cm from the fascial edge. Tera and Aberg, as cited by Poole,[19] discovered that the greatest tissue-holding power (22.9kg) in human cadavers was obtained in vertical incisions through the linea alba, which had been closed with sutures placed lateral to the transition between the linea alba and the rectus sheath, with the medial aspect of the rectus abdominis muscle being included within the suture.

Upper abdominal incisions are believed to be less secure than lower abdominal incisions. Various studies done on this aspect have been either retrospective or uncontrolled. The only experimental study on this problem is done by Poole et al, as cited by Poole[19], who found that vertical midline wounds were more likely to rupture in the upper third than in the middle or lower third. This difference may be due to the relative fixation of the upper abdominal musculo-aponeurotic layers to the narrow angle between the ribs, which limits wound elongation and consequently causes a greater tension at the fascia-suture interface.

The length of the wound is another factor that may influence the risk of dehiscence. Bucknall et al[16] and Pollock et al[21] both found that wounds longer than 18 cm were more prone to disrupt, although Greenall et al, as cited by Poole,[19] were unable to reproduce this finding.

Another aspect to be considered is the use of electrocautery versus a sharp scalpel. Greenburg et al, as cited by Poole[19] believed that opening the fascia with electrocautery in the coagulation mode may cause fascial necrosis and subsequent wound disruption. This finding was refuted by Kearns et al[22] in a randomized clinical trial which demonstrated that electrosurgical midline incision was better than using a scalpel with regard to incision time, blood loss, early post-operative pain, and analgesia requirement.

WOUND HEALING

In 1929, Howes et al[23] stated, “the incised wound presents for analysis the simplest form of disease, for the injury is primarily mechanical and finished and the reparative process is not subject to the interference of further injury.” Yet, when one considers that in the healing wound, cell and tissue production is proceeding at a rate that exceeds that seen in most malignant tumours, it is humiliating to admit how little we know of the mechanisms involved.[24]

The strength of the anterior abdominal wall is in the fascial layer. In the 1950s the wound-healing curve described that the healing process of abdominal fascia after surgical incision continued for 9 to 12 months. During the first four days post-wounding, the wound strength is merely that of the suture material. At 35 days, the wound regains 30% to 40% of its strength. Abdominal fascia regains only 51% to 59% of its original tensile strength at 42 days, 70% to 80% at 120 days, and 73% to 93% by 140 days. Tensile strength never rises to higher than 93% of the strength of unwounded fascia.[11]

Wound healing is a complex (but orderly) phenomenon involving a number of processes, including induction of an acute inflammatory process by the wounding, regeneration of parenchymal cells, migration and proliferation of both parenchymal and connective tissue cells, synthesis of extracellular matrix proteins, remodeling of connective tissue and parenchymal components, and collagenization and acquisition of wound strength.[25]

The mechanism of wound healing is a dual process consisting of cellular and vascular elements. There is an initial vaso-constriction as a result of wounding, which is followed by the process of repair, with angiogenesis and fibroblast proliferation laying down collagen, thus forming granulation tissue.

The different histological aspects of the healing process observed in the rat model were studied by Bucknall[24] who reported that the non-infected

healing wound displayed an organized process of repair with capillary budding and the formation of granulation tissue. Infected wounds, however, were more disorganized with abscess formation and capillary hemorrhage giving the appearance of an acute inflammatory reaction rather than a uniform healing process.

Fibroblasts have been identified as the active agents in the reparative process. These were seen in abundance in non-infected wounds, but infection caused a reduction in the number of active fibroblasts, and the collagen produced was disorganized. Therefore infected wounds were significantly weaker than controls almost certainly due to decreased fibroblast concentration and activity. This confirms what John Hunter[26] wrote in 1790, "A wound will not heal while there is slough to separate."

FACTORS INFLUENCING WOUND HEALING

There are various factors that predispose an individual to develop post-operative wound complications. These include a patient's demographic profile such as age and gender. Co-morbid illnesses such as diabetes, hypertension, renal failure, jaundice, malignancy, and hemodynamic instability; lifestyle factors such as smoking, alcohol consumption, obesity, and under-nutrition have all proven to be detrimental to wound healing. Certain iatrogenic causes such as prolonged mechanical ventilation, chronic steroid intake, antimitotic drugs, anticoagulation therapy, and

radiation therapy also impair wound healing and predispose to wound complications.

Studies have shown that wound disruption is more likely to occur in patients over 65 years of age undergoing major abdominal surgery. This has been a consistent finding in literature with some authors suggesting increased risk in patients over 70 years of age, in patients over 64 years of age, or in patients over 50 years of age.[27]

Male predisposition to developing wound disruption was nearly two and a half times more than females. Female-to-male ratios have previously been reported to be 1:1.6, 1:2.4, and 1:3.[27] Nonetheless, the gender of the patient, being an independent risk factor, cannot be controlled by the surgeon.

Pulmonary disease and post-operative pulmonary complications (atelectasis, bronchitis, and pneumonia) are important systemic factors. The propensity for fascial disruption is due to increased intra-abdominal pressure experienced by the coughing patient during early wound healing.

Hypoalbuminemia was a consistent predictor of wound disruption and has been shown in literature to decrease tensile strength of wounds. Alexander and Prudden[28] noted that 53% of patients with dehiscences had serum albumin levels less than 3 gm%, compared with only 9% in the control group.

A study by Pitkin[29] in 1976 noted a ten-fold increase in deep wound separation in the obese as compared with normal-sized women undergoing hysterectomy. Goodson and Hunt, as cited by Riou et al[27] have noted deficient collagen formation and consequent poor tensile strength in both experimental and clinical models of obesity.

Diabetes, hypertension, anemia, renal failure, jaundice, and malignancy have been proven to adversely affect wound healing. Corticosteroids reduce the initial inflammatory response to wounding and delay fibroplasia, besides decreasing the tensile strength of wounds. Smoking and alcohol consumption hamper wound healing.

The placement of colostomies or drains within the wound introduces an inherent risk for infection and facial weakening and may predispose to wound disruption.

Peri-operative antibiotic therapy plays an important role in preventing and treating bacterial contamination of wounds, thus decreasing the incidence of wound disruption.[30] Improved monitoring devices and quality of intensive care have helped in preventing wound complications.

GENERALIZED PERITONITIS AND THE CONTAMINATED WOUND

Peritoneal inflammation arising as a consequence of contamination from an intra-peritoneal organ is known as secondary peritonitis. The components and functions of the intra-peritoneal organ systems are diverse. The sequence of both local and systemic responses to secondary peritonitis; however, is relatively constant. The diagnosis of peritonitis is usually made by clinical evaluation. The management of peritonitis is influenced significantly by the etiology of the infectious process.[31]

The majority of these episodes are the result of primary lesions of the alimentary tract. About 10% of cases are caused by complications of surgery. The overall mortality of generalized secondary peritonitis varies from 10% to 40%. A diagnosis of secondary peritonitis demands active intervention. Aggressive antimicrobial therapy as well as physiological support is imperative. The primary objectives in the treatment of secondary peritonitis are 1. fluid resuscitation, 2. initiation of antibiotic therapy, 3. elimination of the source of bacterial contamination, 4. reduction of the bacterial innoculum, and 5. continued metabolic support.[31]

With the advent of modern technology, equipment, and antimicrobial therapy, the mortality following generalized peritonitis secondary to hollow viscus perforation is steadily on the decline. Although the surgeon has been able to surgically correct various disease processes in the abdomen, he has been unable to convincingly tackle a more 'superficial' but pertinent problem: post-operative abdominal wound complications.

In secondary peritonitis, gross intra-abdominal contamination is the norm. This may consist of pus, feces, bile, and reactionary fluid. During the surgical correction of the hollow viscus perforation and peritoneal toilet, contamination of the incised wound is inevitable. This results in a high risk wound making it more susceptible to post-operative wound complications such as wound infection, wound dehiscence, burst abdomen, and incisional hernia.

WOUND INFECTION

Moynihan[2] said, "Every operation in surgery is an experiment in bacteriology." The occurrence of post-operative wound infection has plagued even the most experienced of surgeons. About 48% of incisional hernia arise from infected wounds.[24] The association between post-operative surgical-site infection and increased hospital costs and resource utilization is well established.[32]

Wound infection may be defined as the presence of pus in the wound, which may or may not be sent for bacteriological culture for confirmation. Edlich et al, as cited by Sharp et al[30] proposed that the earliest evidence of clinically purulent discharge prior to development of spontaneous wound drainage occurred on the fourth day following an insult.

Almost all post-operative wound infections are initiated along and in the vicinity of suture lines. It has been demonstrated that the presence of suture material in the wound increases the susceptibility of host tissue to infection. Suture materials can also serve as a vehicle for mechanical transport of bacteria into the surgical wounds. This physical process may be aided further by the capillary action of the suture materials, especially the polyfilament ones.[33]

The majority of infections start on the mucous membranes through microbial attachment with or without significant penetration. Different micro-organisms have different surface characteristics, which could also contribute to the selective adherence of bacteria to foreign materials. The inoculation of a certain number of bacteria into a wound does not necessarily result in the development of a wound infection. The extent of

contamination is the key. Elek and Conen, as cited by Chu et al[33] demonstrated that $7.5x10^6$ viable Staphylococci were normally required to induce infection intradermally, whereas as few as 300 bacteria were needed to elicit a similar infection in the presence of a silk suture.

Studies have shown that attachment of bacteria on a suture surface was not time independent but a dynamic phenomenon. This indicates that the attachment of bacteria on a suture surface is a reversible process. This reversible attachment of bacteria could turn into an irreversible process if there is a firm adhesion of bacteria to the suture's surface by way of an extracellular adhesive medium. Staphylococcus produces a glycocalyx adhesive matrix, which irreversibly binds to the suture surface.

Besides suture material and lack of aseptic precautions, various other factors predispose an individual to wound infection and wound failure. Dennis and Edip, as cited by LoCicero et al,[34] reported that the problems of greatest concern during wound closure are bacterial contamination, hemostasis, fascial approximation without strangulation, minimal tissue damage, and obliteration of dead space. Prudent use of prophylactic antibiotic therapy, improvements in intestinal preparation, and adequate wound irrigation are factors which decrease wound contamination.[34]

WOUND DEHISCENCE

Wound dehiscence is defined as post-operative wound separation that involves some but not all the layers of the abdominal wall. Clinical dehiscence usually occurs 6 to 10 days after surgery.[35] This period of repeated stress and strain cannot be reproduced in any in-vitro model. Despite the significant advances in peri-operative care over the last few

decades, the incidence of abdominal wound dehiscence and its associated mortality has not improved.

From 1950 through 1984, 34 clinical reviews of abdominal fascial disruption were published in major medical and surgical journals. All reviews were based on large experiences, ranging from 1,000 to nearly 40,000 laparotomy wounds. Overall there were about 1,900 dehiscences after more than 320,000 operations, for a mean incidence of 0.59% (0.24%-5.8%). This figure is definitely an understatement and most prospective studies of wound disruption report incidence rates of 1% to 3% after major abdominal operations, with an associated mortality rate of 12% (9% to 44%).[36] This high mortality rate reflects the serious underlying conditions that predispose to dehiscence, as well as added deaths as a result of the open abdomen and a second operative procedure.[35]

Greenburg et al, as cited by Poole[19] stated that the incidence of wound dehiscence has stabilized at about 0.5%. Recent decrease in mortality associated with dehiscence has also been reported. This is more a reflection of better peri-operative and post-operative care rather than technical advances in wound closure.

In recent reviews, two factors seem to be of major importance in wound dehiscence. They are: wound infections as noted by Halasz et al[37] and Higgins, et al[38] and increased intra-abdominal pressure. Raised intra-abdominal pressure may be caused by abdominal complications (vomiting, ileus, or bowel obstruction), pulmonary complications (atelectasis, bronchitis, or pneumonia), or the nature of the operation (for example, repair of a diaphragmatic hernia).[39] Prevention of wound dehiscence is

aimed at increasing the strength of the sutured wound, decreasing intra-abdominal pressure, or both.[40]

There are three possible technical causes of dehiscence. The knots may slip, the suture may break, or the suture may tear through tissue and pull out. Jenkins[12] suggested that adequate strength of suture material will prevent suture breakage, efficient knots will prevent knot slippage, and a sufficiently small stitch interval will prevent protrusion of abdominal contents into the intact wound. To prevent sutures from cutting out, he suggested using a suture length-to-wound length ratio of greater than 4:1; taking large bites of greater than 1 cm and using thick suture material. Maximum resistance to pull-out is obtained with bites of at least 1.2 to 1.5 cm. Thick suture material provides greater residual strength during the suture absorption process and it caused less cutting of the fascia. It also provides adequate elasticity to accommodate an increase in intra-abdominal pressure in the post-operative period. Thus the surgeon's surgical technique is directly responsible in preventing wound dehiscence.

BURST ABDOMEN

Burst abdomen is defined as post-operative wound separation that involves all layers of the abdominal wall with protrusion of abdominal viscera through the wound.

Norris, as cited by Bucknall and Ellis,[41] reported an incidence of 0.56% burst abdomen in 2,318 laparotomies and stated: 'The elimination of post-operative wound dehiscence is entirely within the jurisdiction of the operating surgeon'. He advocated retention sutures placed through all layers at an optimum distance from the wound margins to ensure their

holding power. The incidence of burst abdomen drastically decreased from 11% to 1.25% when in 1941, Jones et al in the Cleveland Clinic used mass closure with stainless steel wire[13]. The application of modern methods of surgery has resulted in the virtual disappearance of burst abdomen. This alarming and dangerous complication, associated with a mortality rate higher than 35% is now a rarity with an incidence below 1%[41].

INCISIONAL HERNIA

Incisional hernia can be defined as a visible bulge when the patient stands up and coughs. In addition, there is a sharp-margined defect in the abdominal wall at the site of the scar. Figures on incisional hernia are not easy to find, but Blomstedt and Welin-Berger, as cited by Bucknall and Ellis[41] reported a 10% incidence following 279 cholecystectomies. Irvin[42] Leaper,[20] Cameron,[4] and others have shown that there is no difference between absorbable and non-absorbable sutures, but there still exists an incisional hernia rate of 3% to 9%. The diagnosis of incisional herniation is subject to wide observer bias and most authors do not explain their method of hernia detection. Although the decrease in incidence of wound dehiscence by the mass closure technique is encouraging, the incidence of late incisional herniation has remained high.

The main causes of incisional herniation are technical inadequacy and wound infection.[43] The majority of these failures occurred within the first 3 months after surgery and possibly result from the disappearance of the suture material before sufficient collagen has been laid down to restore intrinsic tensile strength. A study done by Bucknall et al[41] decreased the

incidence of incisional hernia to 3.8% by using monofilament nylon, a non-absorbable suture material.

The part played by wound sepsis is important. Bucknall et al[15] reported that 48% percent of patients with incisional hernia had wound infection. Fischer and Turner[44] (1974), found that 88% of patients with incisional hernia requiring repair had previously had wound infection. Pollock, Greenall, and Evans[21] reported that the incidence of incisional hernia would be reduced by the elimination of wound sepsis. This has been shown to be the most significant factor in the development of incisional hernia.

Other factors also play a role in the development of incisional hernia. There is a significant association between increasing age and formation of hernia. The incidence of wound herniation in men was three times that of women. Pitkin[29] and Baggish and Lee[45] exonerated obesity as a significant predisposing factor with a ten-fold increase in wound separation. Irvin et al[42] (1976) found a higher incidence of wound failure in the hands of surgeons in training than in the more experienced consultants.

Late discovery of incisional hernia is well known.[46] Most incisional hernia are not recognized by patients themselves. The expression 'late discovery' rather than late development is used due to experimental evidence of the movement of metal clips placed on the opposed aponeurotic edges at the time of closure suggests that when clips are shown on X-ray to be together 1 month after operation, they do not subsequently separate and the wound does not herniate. The development of an incisional hernia is almost inevitable when early post-operative X-rays show clip separation. This may

not be discovered until months or years later.[47] Thus, the importance of early post-operative wound security cannot be over-emphasized.

SUTURE SINUS AND POST-OPERATIVE WOUND PAIN

Non-absorbable sutures have been shown to be more resistant to wound infection and provide better wound security than their absorbable counterparts. The enthusiasm in their usage has, however, been dampened by the higher incidence of sinus formation, wound pain, and button-hole hernia formation. Rates of 8% for suture sinus and 17% for scar pain associated with the use of permanent sutures have been reported.[8, 24, 48]

The incidence of chronic wound pain and suture sinus formation has been found to be significantly less with absorbable material[11]. Leaper, Pollock, and Evans[20] in 1977, reported a zero incidence of sinuses when polyglycolic acid was used.

The frequency of suture sinus is directly related to the degree of contamination. Cutler and Dunphy, as cited by Bucknall and Ellis[41] found a sinus rate of 2.3% in clean wounds but 80% in infected wounds. Monofilament stainless steel wire rarely produced sinuses in clean wounds unless the suture breaks.

Absorbable suture in the presence of infection does not undergo total fragmentation and absorption and may result in the development of a suture sinus. Thus the direct relationship between sinus formation and wound infection reported by previous investigators is confirmed.[24]

CHOICE OF SUTURE MATERIAL

We have noted earlier that the surgeon has a vital role to play in preventing wound complications. The two main things within his direct control are: 1.Choice of suture material and 2.Technique of fascial closure.

A suture material can either make or break abdominal wall closure. Rodeheaver[49] stated that during the early phases of wound repair, before healing has started, the life and health of the patient are 'hanging by a thread'. The purpose of the sutures is to co-apt the wound edges and to act as a splint while the dense fibrous scar deposits and matures. We now have more than 50 different types and shapes of suture materials plus a variety of lubricating coatings.[30] Despite advances in suture technology, many surgical procedures are still performed with poor-quality, out-moded suture materials.

Sutures are judged by three criteria: (1) handling characteristics, (2) healing characteristics, and (3) resistance to infection. Handling properties include ease of knot tying, holding ability, and ease of sliding through the tissue. The healing of all wounds depends on many factors including: surgical technique, blood supply, host defense mechanism, absence of infection, and, least important, the suture itself (although in the presence of infection, the suture assumes a more important role). A suture can hold bacteria in its interstices for long periods of time; injure the surrounding tissue, promoting infection. It is eventually eliminated from the body via a sinus tract through the wound, i.e., the spitting suture, or disrupt, resulting in hernia formation.[30]

Suture materials can be classified into various groups based on different characteristics: synthetic versus natural, absorbable versus non-absorbable, monofilament versus multifilament. Natural sutures include cotton, silk, linen, catgut, and steel; whereas synthetic sutures are nylon, polyglactin, polyglycolic acid, polypropylene, Dacron, and the more recent polydioxanone. Nylon, stainless steel, polypropylene, and polydioxanone can be used in their monofilament states. All other suture materials, including nylon and stainless steel, are used also in the form of multi-strands, i.e., braided, woven, or twisted. Lubricants such as beeswax, silicone, Teflon, or polybutalate have also been added to many sutures.

The surgeon has always searched for the ideal suture material. The ideal suture characteristics include: (1) good knot security, (2) superior tensile strength, (3) excellent handling characteristics, (4) minimal tissue reaction, (5) absence of allergenic properties, (6) resistance to infection, and (7) eventual absorption when tissue repair is complete.

Catgut, as advocated by Moynihan[2] in 1920, was for many years the suture material of choice. But it has been shown that absorption of catgut may occur before the wound repair has achieved adequate tensile strength. In fact, catgut has been shown to give only erratic and unreliable support to a wound during the first 10 days.[50] This led to the discovery of a non-absorbable suture material: stainless steel. The main disadvantage of stainless steel sutures is its difficulty in handling and tying as well the tendency to develop fractures. Being non-absorbable, it causes post-operative wound pain and can cause sinus formation. Silk, organic in nature, is a braided suture material. It is a long-lasting biomaterial. It was

found to be very reactive, particularly when infected, with large abscess dotted along its length. Silk sutures lost up to 83% of their original strength after 70 days.[24]

The physical characteristic of braiding induces reactivity and abscess formation when used in infected wounds. Experimental studies have shown that multifilament sutures result in a higher incidence of wound complication than monofilament sutures.[24,30,33] This may be related to capillary forces of the multifilament sutures picking up bacteria into the sutures, where they subsequently escape phagocytosis. Thus the monofilament suture is associated with a lower incidence of wound infection.

The advent of synthetic sutures has revolutionized abdominal wall closure. They are available in the form of non-absorbable sutures like nylon, polypropylene, polyethylene, and polyamide; slowly absorbable sutures like polyglyconate and polydioxanone; and absorbable sutures like polyglactin 910 and polyglycolic acid.

Non-absorbable materials have been widely used in abdominal fascial closure since the 1970s. Non-absorbable monofilament suture materials have been shown to have more tissue reactivity than stainless steel, but less than absorbable sutures. They are more resistant to infection (based on their physical configuration more than the surface finish) than absorbable sutures[33]; but their use is associated with a higher incidence of sinus formation, wound pain, and button-hole hernia. (A button-hole hernia develops lateral to the main incision in association with progressive enlargement of the needle hole through which the permanent suture

material passes). The benefit of non-absorbable material lie in the fact that they retain their strength as the fascia develops intrinsic strength in the process of wound healing.[7,11,41]

Nylon has been used in abdominal wound closure for long. It is cheap and chemically inert. It produces less tissue reaction, necrosis, and infection than do smaller multifilament suture material of other compositions. It allows early change from polymorphonuclear leucocytes to lymphocytic response. Polypropylene is a non-absorbable synthetic suture material. Its tensile strength and inert properties make it suitable for abdominal closure. The main faults of polypropylene are the necessity of many throws to secure a knot and its non-absorbability. It also has a tendency to fracture. It was the suture material of choice until recently.

Absorbable materials are designed to approximate the fascia during the critical early healing period and subsequently to undergo absorption to avoid the complications of hernia formation, wound pain, and buttonhole hernia associated with usage of non-absorbable sutures.

Polyglycolic acid is a rapidly absorbable synthetic suture. It was the first synthetic absorbable suture to be introduced in 1969. It is relatively easy to handle and is known for its knot security. It loses over 90% of its strength within three weeks, whereas the abdominal wall fascia requires about 120 days to regain its strength. In most circumstances, this strength is sufficient to hold the fascia together, but with delayed healing (infection) or raised intra-abdominal pressure (post-operative chest infection or abdominal distension) the strength of the wound without suture support may be insufficient, leading to the formation of an incisional hernia. Therefore, the

need to monitor the use of synthetic rapidly absorbable materials for abdominal wall closure remains.

Polyglactin 910 is a braided material but is less reactive than silk or catgut because, like polyglycolic acid, it is absorbed by hydrolysis. Its absorption may be delayed by infection, and it may act as a focus for infection and as a foreign body with associated delay in healing. The rapidly absorbable suture materials have been associated with increased rates of incisional hernia formation when compared with non-absorbable sutures[11].

The search for the ideal suture material continues. The 'closest' to ideal suture to date is the second-generation polydioxanone (PDS) suture. It is a synthetic slowly absorbable monofilament suture material with properties similar to that of polyglycolic acid and polyglactin 910 sutures. It was developed to overcome the problem of tissue drag and knot slipping found in braided synthetic absorbable sutures. Its handling properties were reported better than even catgut.[51] The inherent flexibility of its polymer allows fabrication of fiber useful for all sizes of suture.[52] It maintains 50% to 70% of its tensile strength for about 4 weeks and about 14% at 8 weeks. PDS has been shown to have 1.7 times the tensile strength of polypropylene,[53] besides being more pliable. In fact, its strength prior to implantation exceeds that of non-absorbable monofilament sutures!

PDS is the suture of choice in closure of the contaminated wound. Chu and Williams[33] studied the effects of physical configuration and chemical structure of suture materials on bacterial adhesion. They concluded that PDS had the lowest average number of adhered bacteria over the same time period as compared to other sutures. This lower bacterial affinity is

believed to be partially due to its monofilament configuration, which has a lower surface area than braided sutures. Its chemical structure contributed to this low affinity; it was found to be more hydrophobic because of the lower amount of the water affinity group (ester group). Absorption of PDS takes about 180 to 210 days. It is absorbed slowly by hydrolysis and is not subject to enhanced absorption by bacterial enzymatic activity. PDS has been formulated to provide wound support throughout an extended healing period as well as to minimize the variability of breaking strength, retention, absorption, and to invoke minimal tissue reaction. These features prove to be particularly beneficial in critical applications, such as those involving slowly healing tissues.

TECHNIQUE OF WOUND CLOSURE

There are various technical details to be considered in closure of the anterior abdominal wall. These include:

1. Layered closure, mass closure, and retention sutures
2. Suture length-to-wound length ratio
3. Continuous closure versus interrupted closure.

MASS CLOSURE VERSUS LAYERED CLOSURE

Layered closure is described as the separated closure of the individual components of the abdominal wall, specifically the peritoneum and the distinct musculo-aponeurotic layers. Mass closure is the closure of all the layers of the abdominal wall (except the skin and subcutaneous tissue) as one structure.

In the past, layered closure of the abdominal wall was advised to promote wound security. This was believed to reduce intra-peritoneal adhesions, increase wound strength, discourage dehiscence, prevent leakage of intra-peritoneal contents, and promote hemostasis. Smead first described mass closure technique in 1900. Jones[54] described the same technique in 1941, and thereafter it was called the Smead-Jones technique. This technique has stood the test of time. Dudley,[55] in an experimental study in 1970, showed that mass closure was superior to layered closure when using stainless steel wire. Goligher[6] in 1975 supported the concept of mass closure by demonstrating a dehiscence rate of 11% with layered fascial closure compared to 1% with mass closure. Ellis and Heddle, as cited by Bucknall and Ellis,[41] reported no significant difference in the rate of dehiscence and evisceration in patients who were closed without suturing the peritoneum when compared with patients who were closed with peritoneal sutures. Keill et al[56] reported wound disruptions more than twice as frequently when the peritoneum was closed as a separate layer. Bucknall et al,[15] in 1982, prospectively studied 1129 abdominal operations and demonstrated that layered closure was associated with a significantly higher dehiscence rate compared with mass closure (3.81% versus 0.76%). Higgins et al[38] noted a decrease in dehiscence rate from 3.7% to 0.7% when the layered technique was abandoned for the far-and-near mass closure technique.

Peritoneal closure has been shown to be associated with increased incidence of adhesions resulting in intestinal obstruction. It compromises the adequacy of closure of the subsequent layers and increases the

duration of operation. There is a statistically significant reduction in hernia formation and dehiscence with mass closure. This is confirmed by recently published meta-analyses by Rucinski et al,[9] van't Riet et al,[10] and Weiland et al.[16]

Retention suture technique (involving the entire thickness of the abdominal wall including skin and subcutaneous tissue), was first described by Reid in 1933. It was to provide additional security to a wound. It lost its popularity as its proposed wound security was mostly hypothetical; it was associated with increased post-operative pain and it made site determination of enteral stomas difficult. Retention sutures have been ineffective in decreasing the incidence of fascial dehiscence.

SUTURE LENGTH-TO-WOUND LENGTH RATIO

Jenkins[12] proposed a mechanical approach to the abdominal wound. He agreed with Dudley[55] that the size of the bite and the diameter of the suture material bear an inverse relationship to the distribution of forces at the suture-tissue interface. Thus, large bites with thick sutures should have lower tendency to cut out than small bites with thin sutures. Jenkins was probably the first to recommend a specific suture length-to-wound length ratio on the basis of clinical studies and mathematical calculations. This ratio depends on the following factors: the size of tissue bites, the distance between bites, and the tension on the suture.

Abdominal closure should be done under minimal tension. The higher ratios of suture length-to-wound length were associated with improved wound healing. These observations linking wound tension with healing outcomes suggest that shorter suture length-to-wound length ratios may be

associated with increased wound tension. This increased wound tension may increase tissue pressure, reducing musculo-fascial microperfusion and perhaps oxygen availability, which is important for optimal healing and host defence.[32] Tissues entangled between sutures under tension develop poor circulation and impaired subsequent healing, leading to increased wound complications.

It has been shown that post-operative abdominal distension could increase the wound length by 30%. Suturing under minimal tension with at least 1 cm bites at 1 cm intervals has been advocated requiring a suture length-to-wound length of 4:1.[57] Varshney et al[58] have taken Jenkins' theory a step further and advocated a six-fold suture length-to-wound length ratio for abdominal closure by considering the third dimension to the abdominal wound: the depth. This enables lengthening of the wound in cases of abdominal distension without the sutures cutting through the tissue and with good wound healing.

CONTINUOUS VERSUS INTERRUPTED CLOSURE TECHNIQUE

The choice between continuous and interrupted technique of closure of the fascial layer is still under dispute. There are advantages and disadvantages of each technique.

Advocators of continuous closure technique cite various advantages. It provides an evenly distributed tension over a continuous line throughout the length of the single suture in the incision. It is a more cost-effective closure requiring half as much time, saving operating and anesthetic time. With only two knots in the closure there is less suture material in the wound, especially at the subcutaneous level.[59] The running closure avoids

trauma to the wound surface related to knot-tying; this is mainly noticed in the appearance of the exposed subcutaneous fat and the absence of liberated fat globules. In addition, defects related to the knot are minimized and the total amount of foreign material in the wound is actually less than with the standard interrupted technique. Bursting strength of a wound is significantly higher when continuous suture technique is used by surgeons[11]. Post-operative pain experienced by a patient may be less due to equal distribution of tension.[60]

The theoretical disadvantage of continuous suture is that the security of the wound is dependent on a single strand of suture material and a limited number of knots. One criticism of continuous closure is that it may cause ischemia and necrosis of fascia with subsequent dehiscence.[3] Disruption of the knot or suture has been shown to cause wound dehiscence. Such is not the case with interrupted technique where even if one suture gives way, the wound would not disrupt due to adjacent secure sutures.

Proponents of the interrupted technique state that the interrupted Smead-Jones technique is the strongest mass closure, though many authors recommend a continuous method because it offers the same wound integrity.[61] For aponeurotic wounds closed with interrupted sutures, it was found that increased tension caused stronger wounds, presumably because of a better orientation of collagen across the wound.

A drawback with the interrupted closure technique is the fact that tension is isolated to each stitch, and disruption begins at the stitch at which tension exceeds the suture-holding capacity of the fascia. The multiple knots

required by the interrupted technique may contribute to wound infection by trapping bacteria, resulting in a high overall infection rate.[62]

The purpose of this study is to determine the current trends in technique of closure of the fascial layer in the Department of General Surgery in our institution and the incidence of wound complications.

STUDIES ON CHOICE OF SUTURE MATERIAL WITH REGARD TO WOUND COMPLICATIONS

Catgut, as advocated by Moynihan in 1920, was for many years the suture material of choice. It is now known that absorption of catgut may occur before the wound repair has achieved adequate tensile strength. Catgut gives erratic and unreliable support to a wound during the first 10 days.[50] Goligher[6] in 1976 showed that it had insufficient strength for use in abdominal wound closure, being associated with an 11% incidence of dehiscence.

Jones, Newell, and Brubaker,[54] in 1941, reported a burst abdomen rate of 11% when incisions were sutured with two layers of catgut and 7% when sutured with catgut for peritoneum and interrupted steel wire for fascial layer. Only one burst abdomen occurred in 81 operations after steel closure with interrupted mass far and near sutures. In paramedian elective laparotomies, Goligher[6] in 1976 reported one burst abdomen and no hernia in 108 cases in which all-coats interrupted wire sutures were used. The use of non-absorbable sutures to close the abdomen was here to stay.

Subsequently various synthetic sutures were discovered. Osther et al[62] demonstrated that monofilament polyglyconate suture reduced the

incidence of wound infection compared with that of multifilament polyglycolic acid suture in patients with suspected impaired wound healing.

Studies done by Bucknall and Ellis[41] found abdominal wound closure with polyglycolic acid sutures to be significantly inferior to nylon with regard to development of incisional hernia. Kirk,[63] in 1972, had no burst abdomen in 186 laparotomies closed with continuous all-coats nylon. Likewise, Martyak and Curtis,[64] in 1976, had neither hernia nor burst abdomen in 280 midline wounds closed with all-layer continuous nylon. Jenkins[12] recorded only one burst abdomen in 1,505 closures with this technique. Ellis and Heddle[65] reported an incidence of only 0.4% burst abdomen when they used a mass closure nylon technique in 250 median and paramedian incisions.

Polyglycolic acid sutures, despite previous satisfactory reports, resulted in incisional hernia rates of about 11%, which is unacceptably high.[21,41] Most of these wound failures occurred within the first three months and possibly result from the disappearance of the suture material before sufficient collagen had been laid down to restore intrinsic strength.

A meta-analysis done by Hodgson et al[66] using nine trials comparing continuous non-absorbable versus continuous absorbable suture technique revealed fewer incisional hernia in the continuous non-absorbable group (OR 0.61, 95 CI 0.46-0.80). A study by Leaper et al[67] and Israelsson and Jonsson[68] showed comparable results between nylon and PDS sutures with regard to wound complications.

STUDIES ON TECHNIQUE OF WOUND CLOSURE WITH REGARD TO WOUND COMPLICATIONS

Certain techniques of wound closure have proven to be consistently effective in preventing wound complications. These include mass closure compared with layered closure. The recommended suture length-to-wound length ratio of 4:1 for abdominal closure has proven true not only theoretically, but also in experimental and clinical studies.[12, 32, 57, 58, 69]

The choice between interrupted and continuous technique of closure still remains the object of contention. Various studies have compared the two with mixed findings:

Fagniez et al[5] did a multi-centric randomized prospective trial of 3,135 patients comparing continuous versus interrupted polyglycolic acid sutures. Contrary to expectations, they noted that the dehiscence rate in the interrupted sutures group was significantly higher than in the continuous sutures group only in the stratum of contaminated wounds. They concluded that abdominal midline incision closure by continuous sutures is at least as good as closure by interrupted sutures, if not better. These results confirm the conclusion of Murray and Blaisdell[14] who stated that a synthetic absorbable continuous suture is as efficient and as strong on the fascia as interrupted sutures.

Colombo et al[46] did a randomized comparison of continuous versus interrupted mass closure using absorbable suture material of midline incisions in patients with gynecologic cancer. In their evaluation of 614 patients, 10.4% in the continuous technique arm developed incisional hernia, which is at the upper limit with respect to early trials of laparotomy

closure. The corresponding figure of 14.7% for interrupted closure was higher than those reported by others. He concluded that interrupted closure was not superior to continuous closure for short and long term wound security. He advocated the continuous method because it was more cost-efficient and faster.

Similar findings have been reported in other studies. Orr et al[70] compared in a randomized manner, continuous and interrupted Smead-Jones technique using polyglyconate sutures in 254 gynecologic patients undergoing vertical midline laparotomy. They recommended the continuous method because it was faster and was associated with fewer wound problems.

Trimbos et al[48] reached the same conclusion when they randomly compared continuous facial suturing with polyglyconate and interrupted closure with polyglactin 910 in 340 gynecologic subjects. They recommended continuous suture technique for its speed, strength, and less foreign-body suture material.

In a randomized trial of both vertical and oblique wounds, Richards et al[3] found no difference in the rate of deep wound dehiscence or the incidence of incisional hernia between continuous suturing and interrupted Smead-Jones suturing in his 571 study patients.

McNeill et al[71] did a prospective randomized comparison of continuous absorbable polyglycolic acid to interrupted non-absorbable monofilament stainless steel wire suture in 105 patients for midline fascial closure following gastric surgery for morbid obesity. He reported no significant difference in the wound complication rate between the two closure

methods. He recommended the continuous technique for its economy of time.

A meta-analysis done by Hodgson et al[66] studied six trials comparing continuous versus interrupted technique (irrespective of suture type). The odds ratio for incisional hernia was significant, favoring continuous closure (OR 0.73, 95% CI 0.55-0.99). There was no statistical difference in the rate of wound infection or wound dehiscence.

In 1998, Weiland et al[16] did a meta-analysis to choose the best abdominal closure technique. Given the lack of significance for wound infections and minimal consideration for rates of dehiscence, the choice of suture material was based on the frequency of hernia formation. This analysis demonstrated that when continuous closure was chosen, non-absorbable sutures are most appropriate; if interrupted closures are chosen, absorbable sutures were preferred. Also if interrupted sutures were chosen for grossly contaminated wounds absorbable sutures would prevent sinus formation.

CONCLUSION

The best method of wound closure is one that maintains tensile strength throughout the healing process with good tissue approximation, does not promote wound infection or inflammation, is well tolerated by patients, and is technically simple and expedient. Despite reports of the merits of absorbable suture material and the benefits of a continuous closure method, many surgeons are reluctant to abandon the time-tested interrupted wound closure technique using non-absorbable materials. This study aspires to observe and record wound complications after midline laparotomy incisions in the hope of spurring renewed interest in abdominal closure, and possibly gathering evidence that warrants change in the current trend, or evidence encouraging the on-going practice.

CHAPTER III

MATERIALS AND METHODS

RESEARCH DESIGN

A descriptive design was used to conduct the study. The purpose of the design was to compare and document the post-operative complications arising with the use of two suturing techniques.

STUDY POPULATION

The population in this study was all patients diagnosed to have generalized peritonitis, and admitted under the General Surgical Units of the Christian Medical College, Vellore.

SAMPLE SIZE

The subjects in this study were all patients diagnosed to have generalized peritonitis and undergoing midline laparotomy. There were 151 subjects enrolled in the study. The rest of the subjects were disqualified from the study for the following reasons: suture technique not known, lost to follow up, and death before 10 days due to causes not attributable to wound complication (discussed in more detail later).

SAMPLING TECHNIQUE

All consecutive subjects who fulfilled the inclusion criteria were included in the study.

INCLUSION CRITERIA

The following criteria were used for selecting the subjects:

1. Patients over 15 years of age.
2. Suture material must be No. 1 PDS.
3. Suturing technique must be either interrupted or continuous.
4. Subjects who had a post-operative follow up of at least 10 days.
5. Subjects who expire within the first 10 days due to a complication under study.

EXCLUSION CRITERIA

The following criteria were used for excluding individuals:

1. Subjects with localized peritonitis.
2. Subjects who underwent any incision other than midline laparotomy.
3. History of previous operation using a midline incision.

DATA COLLECTION INSTRUMENT

A proforma (see Appendix) was developed by the investigator to obtain the demographic and clinical data of the subjects in the study.

Description of the instrument

The instrument consisted of two parts:

Part A: Demographic Data

The demographic data included the following information of the patient: age, sex, hospital number, date of admission, date of operation, date of discharge, number of post-operative outpatient visits, and period of post-operative follow-up in the hospital.

Part B: Clinical Data

The instrument sought to obtain information about the patients' health status: presence of comorbid illness, lifestyle factors, the diagnosis of the patient, the focus of insult, the operation done, the need for stoma, admission in the surgical intensive care unit for monitoring/mechanical ventilation, post-operative complications identified and method of management of the complications, the length of hospital stay, and the period of follow-up in the out-patient department.

PILOT STUDY

A retrospective pilot study was done from September 1, 2003 to December 31, 2004, to determine the sample size and the need for modifications in the instrument. There were 200 subjects in the pilot study. The suture material used was not known in 24 subjects while a combination of different suture materials was used in 12 subjects. In the remaining 164 subjects for whom No. 1 PDS was used for closure, 37 were found to have closure by the interrupted technique and 21 by the continuous technique. There were 102 subjects where technique of closure was not available.

At the end of the pilot study modifications were made in the instrument. More risk factors of wound healing were included: diabetes mellitus, hypertension, jaundice, renal failure, pulmonary disease, anemia, hypoalbuminemia, enteric fever, heart disease, malignancy, presence of stoma, admission to the surgical intensive care unit (SICU), and need for mechanical ventilation.

METHOD OF DATA COLLECTION

Data collection was done from August 20, 2005, to December 31, 2006. The subjects were identified from their case records and the operation notes as entered by the operating surgeon. As this was an observational study, patients were included in each arm of the study based on the technique of fascial closure on the discretion of the operating surgeon. All the subjects who fulfilled the inclusion criteria were included in the study. The investigator explained the nature and purpose of the study, assured confidentiality of the subject, and obtained a verbal consent. The details of the subject were then obtained from the subjects' case record.

The clinical variables were assessed systematically and categorized as follows:

Diabetes mellitus: declared history or blood glucose level values (random blood sugar >200 mg%)

Hypertension: declared history or more than two sequential elevated blood pressure recordings (systolic blood pressure >140 mm Hg and diastolic blood pressure >90 mm Hg)

Jaundice: assessed clinically and biochemically if indicated (serum total bilirubin >1.0 mg%)

Renal failure: assessed biochemically (serum creatinine >1.4 mg% or urea >45mg%)

Pulmonary disease: declared history and radiologically (chest X-ray)

Anemia: assessed pathologically (Hb <10.0 gm% or PCV <30%)

Hypoalbuminemia: assessed biochemically (serum albumin <3.5 g%)

Enteric fever: assessed by positive culture reports or raised antibody (Widal)

Heart disease: based on declared history, electrocardiographic changes, or echocardiography

Nutritional status: based on body mass index values (weight in kg/ height^2 in metres)

Obesity: BMI >25

Normal: BMI 20.1 - 24.9

Underweight: BMI <20

Malignancy: based on history or histopathological analysis

Smoking: based on history

Alcohol intake: based on history

Focus of insult: based on documented operation findings

Stoma: clinical assessment and operation notes

SICU admission: based on inpatient records

Mechanical ventilation: based on inpatient records

DATA ANALYSIS

1. Post-operative complications were presented using descriptive statistics.

2. Test for proportions was used to compare the post-operative complications in each group.

3. Chi-square analysis was used to determine the association between the suturing technique used and the post-operative complications.

4. The association of post-operative complications with the demographic and clinical variables was assessed using chi-square analysis.

PROTECTION OF HUMAN SUBJECT

The pilot study and data collection was done after obtaining approval from each of the Heads of General Surgery Units I – VI. The patient/relatives were informed of the study, and verbal consent obtained. All the data obtained was kept confidential.

CHAPTER IV

DATA ANALYSIS AND STUDY FINDINGS

This section deals with the analysis and interpretation of data. Data was collected from 229 participants. Among them, 151 fulfilled the inclusion criteria and were incorporated into the study. Descriptive statistics was used to present the post-operative complications. Chi-square test was used to determine the association between the suturing technique used and the post-operative complications. The association between the post-operative complications and the demographic and clinical variables was assessed using chi-square test.

The data and the results of the statistical analysis are presented as follows:

Section I:

Distribution of demographic variables (Figures 1 & 2).

Distribution of clinical variables (Table 1, Figures 3 – 6).

Distribution of risk factors between the suturing techniques (Table 2).

Section II:

Comparison of post-operative complications between the suturing techniques (Figure 7).

Association of the suturing technique with the post-operative complications (Table 3).

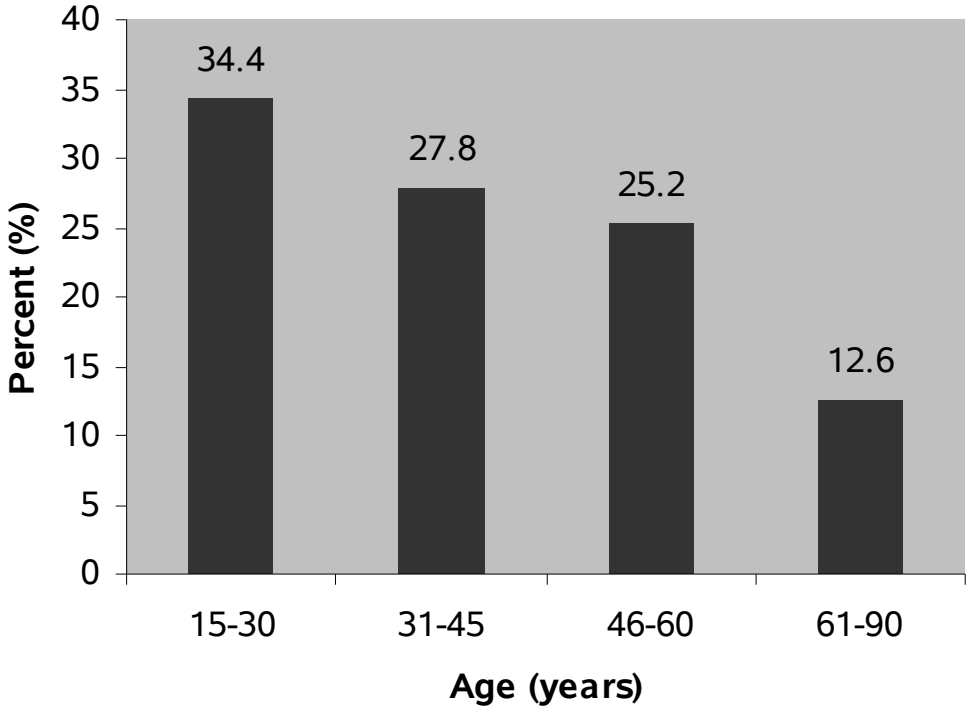
Section III:

Association of the post-operative complications with the demographic and clinical variables (Tables 4 & 5, Figure 8).

SECTION I

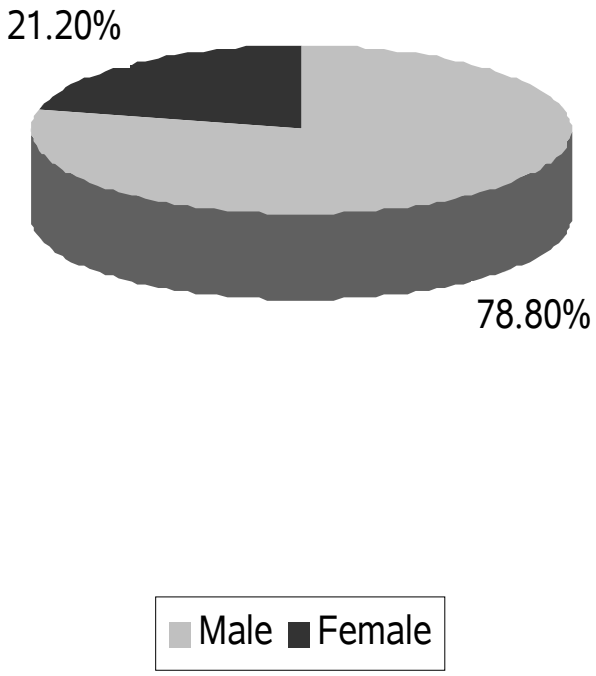
Distribution of demographic variables

Figure 1: Age distribution



Over half of the subjects (62.2%) were 45 years of age or less, while elderly subjects represented only 12.6% of the study sample.

Figure 2: Gender distribution



This demonstrates that most of the subjects (78.8%) were men while only 21.2% were women.

Distribution of clinical variables

Table 1: Prevalence of risk factors

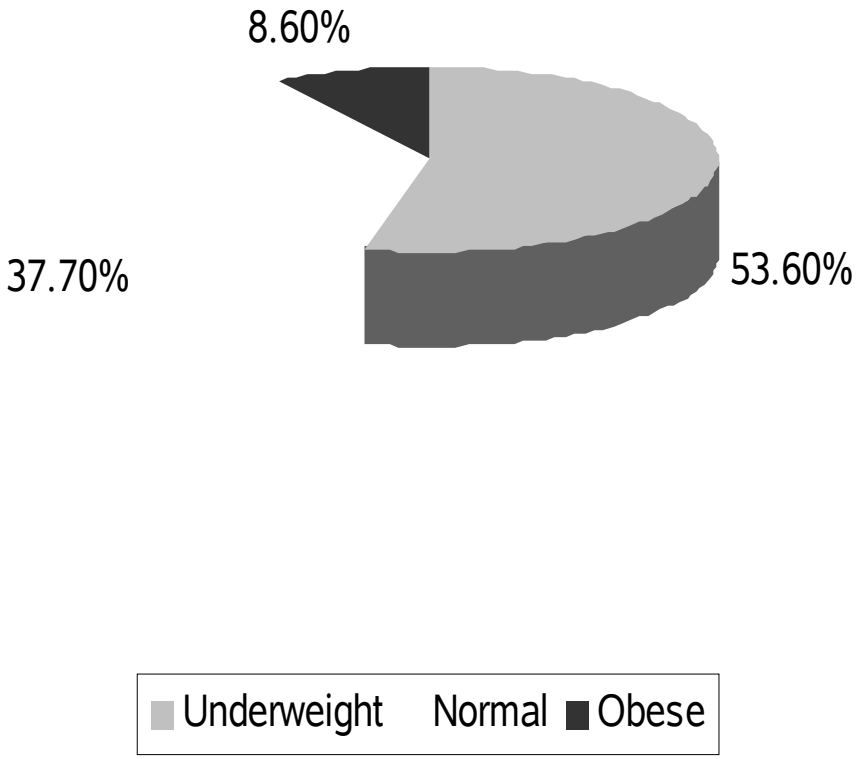
n = 151

S.No	Clinical Variables	Yes	%
1.	Diabetes Mellitus	11	7.3
2.	Hypertension	9	6
3.	Jaundice	11	7.3
4.	Renal Failure	23	15.2
5.	Pulmonary Disease	44	29.1
6.	Anemia	22	14.6
7.	Hypoalbuminemia*	41	85.4
8.	Enteric fever	8	5.3
9.	Heart Disease	6	4
10.	Malignant Disease	6	4
11.	Smoker	58	38.4
12.	Alcoholic	41	27.2
13.	Stoma	12	7.9
14.	SICU Admission	56	37.1
15.	Mechanical Ventilation	55	36.4

(* Serum albumin levels were checked for 48 subjects)

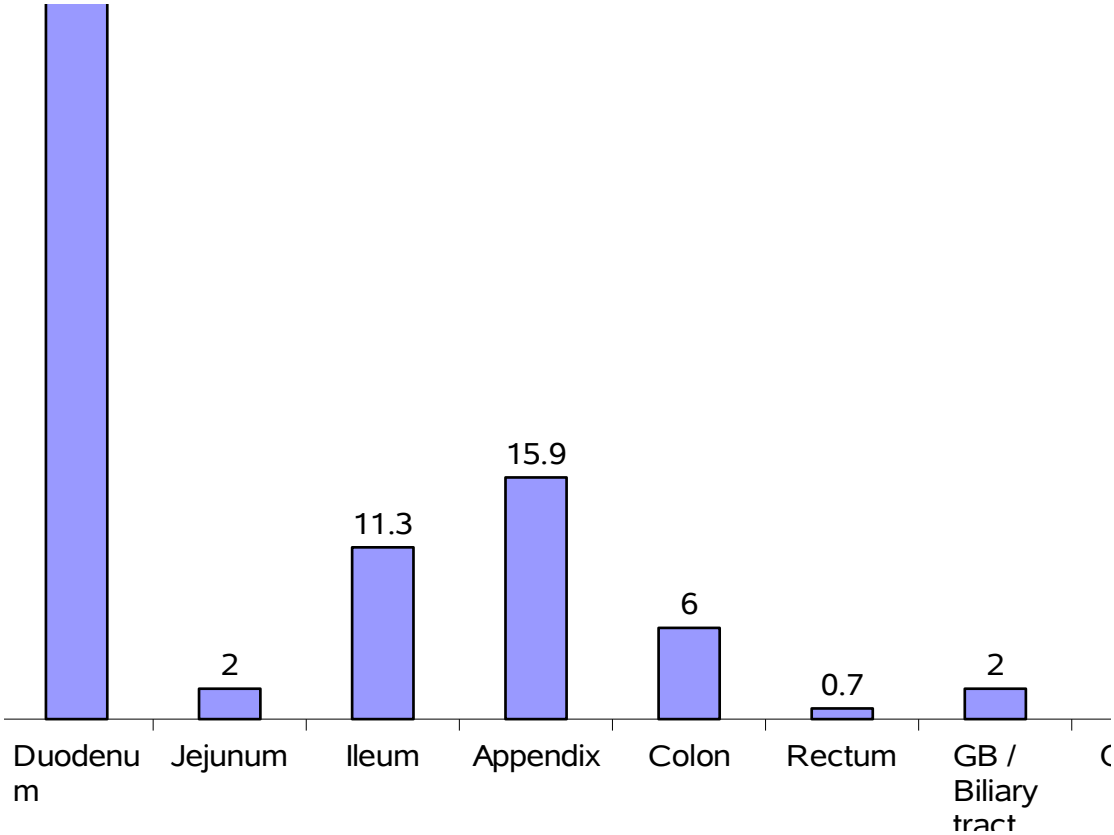
The most prevalent risk factors in descending order were hypoalbuminemia (85.4%), cigarette smoking (38.4%), SICU admission (37.1%), mechanical ventilation (36.4%), pulmonary disease (29.1%), and alcohol consumption (27.2%).

Figure 3: Distribution of nutritional status



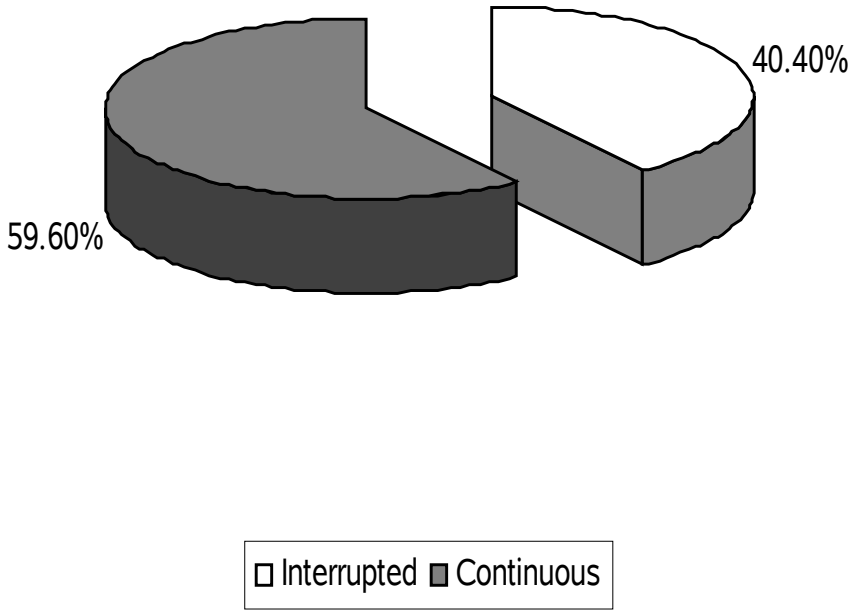
The above figure shows that most of the subjects were underweight (53.6%) while 8.6% of them were obese. Only 37.7 % of the subjects had an acceptable body mass index.

Figure 4: Distribution of site of perforation


2
11.3
15.9
6
0.7
2
Duodenum
Jejunum
Ileum
Appendix
Colon
Rectum
GB / Biliary tract

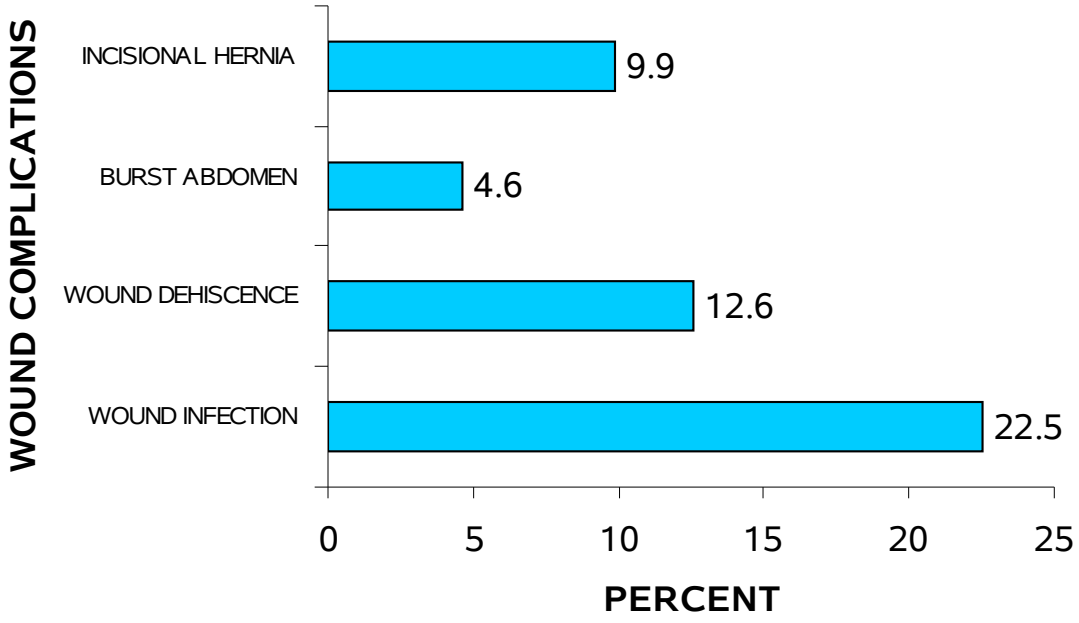
The site of perforation leading to peritonitis in the majority of subjects was the duodenum (57%). Other significant causes were appendicular (15.9%) and ileal (11.3%) perforations.

Figure 5: Distribution of suturing technique



The interrupted technique was used for 61 out of 151 (40.4%) subjects, whereas the continuous technique was used for the remaining 90 subjects (59.6%)

Figure 6: Distribution of wound complications



The above figure demonstrates that 22.5% of the subjects developed wound infection, 12.6% had wound dehiscence, 4.6% had burst abdomen, and 9.9% of the subjects developed incisional hernia.

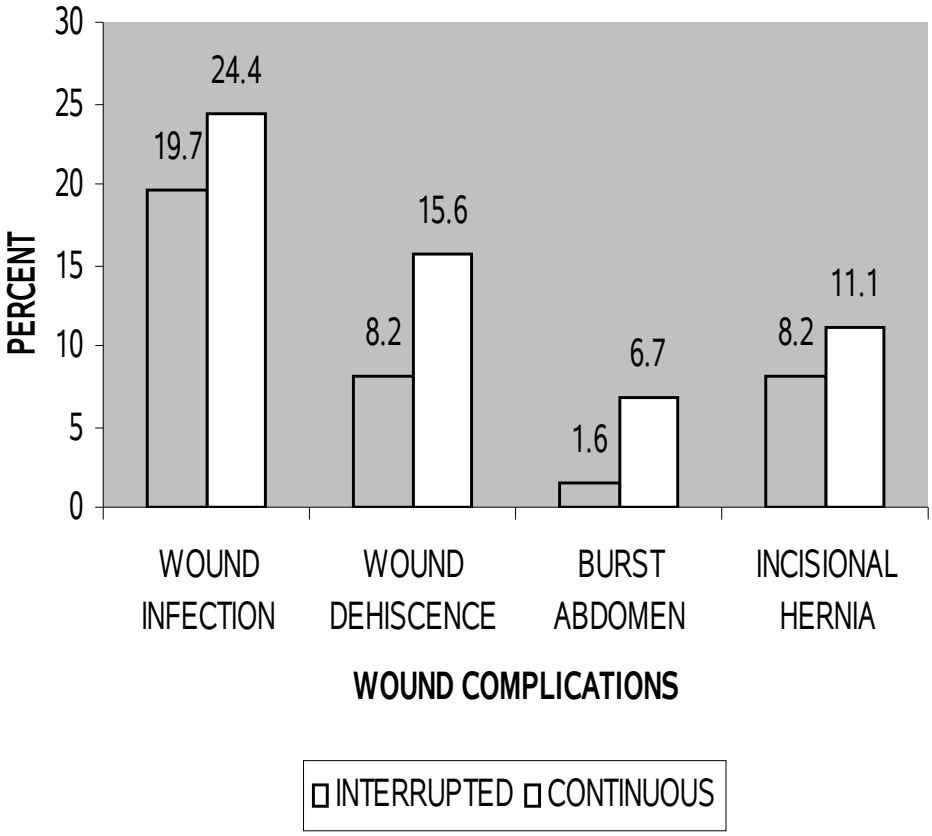
Table 2: Distribution of risk factors between the suturing techniques

No. of risk factors	Closure Technique			
	Interrupted (N=61)		Continuous (N=90)	
	No.	%	No.	%
None	4	6.5	10	11.1
1	10	16.4	19	21.2
2	5	8.2	8	8.9
3	14	23.0	13	14.4
4	6	9.8	13	14.4
5	12	19.7	11	12.2
>6	10	16.4	16	17.8

The above table demonstrates that the risk factors were evenly distributed between the two suturing techniques (p=0.42).

SECTION II

Figure 7: Comparison of post-operative complications between the suturing techniques



In each of the complications studied, a higher percentage of complications were seen in subjects who underwent abdominal fascial closure using the continuous technique.

Table 3: Association of suturing technique with post-operative complications

S.No	Complications		Interrupted (N=61)		Continuous (N=90)		Chi-square
			No.	%	No.	%	
1.	Wound infection	Yes	12	19.7	22	24.4	0.47*
		No	49	80.3	68	75.6	
2.	Wound dehiscence	Yes	5	8.2	14	15.6	1.79*
		No	56	91.8	76	84.4	
3.	Burst abdomen	Yes	1	1.6	6	6.7	2.07*
		No	60	98.4	84	93.3	
4.	Incisional hernia	Yes	5	8.2	10	11.1	0.34*
		No	56	91.8	80	88.9	

*(p > 0.05)

The above table demonstrates that the complications observed with the continuous technique are higher than those with the interrupted technique. However, the difference is not statistically significant.

SECTION III

Table 4: Association of post-operative complications with the demographic variables

n = 151

S.NO	DEMOGRAPHIC VARIABLES	WOUND COMPLICATIONS							
		Wound infection		Wound dehiscence		Burst abdomen		Incisional hernia	
		Yes	No	Yes	No	Yes	No	Yes	No
1.	Age: 15 – 30 years	12	4	7	45	1	51	3	49
	31 – 45 years	11	31	4	38	2	40	5	37
	46 – 60 years	8	30	3	35	1	37	3	35
	61 – 90 years	3	16	5	14	3	16	4	15
	p value	0.83		0.22		0.08		0.26	
2.	Gender: Male	26	93	16	103	7	112	10	109
	Female	8	24	3	29	0	32	5	27
	Chi – square	0.14		0.38		1.97		1.47	

There was no significant association between increasing age of the subject or the gender with the development of wound complications (p>0.05).

Table 5: Association of post-operative complications with the clinical variables

n= 151

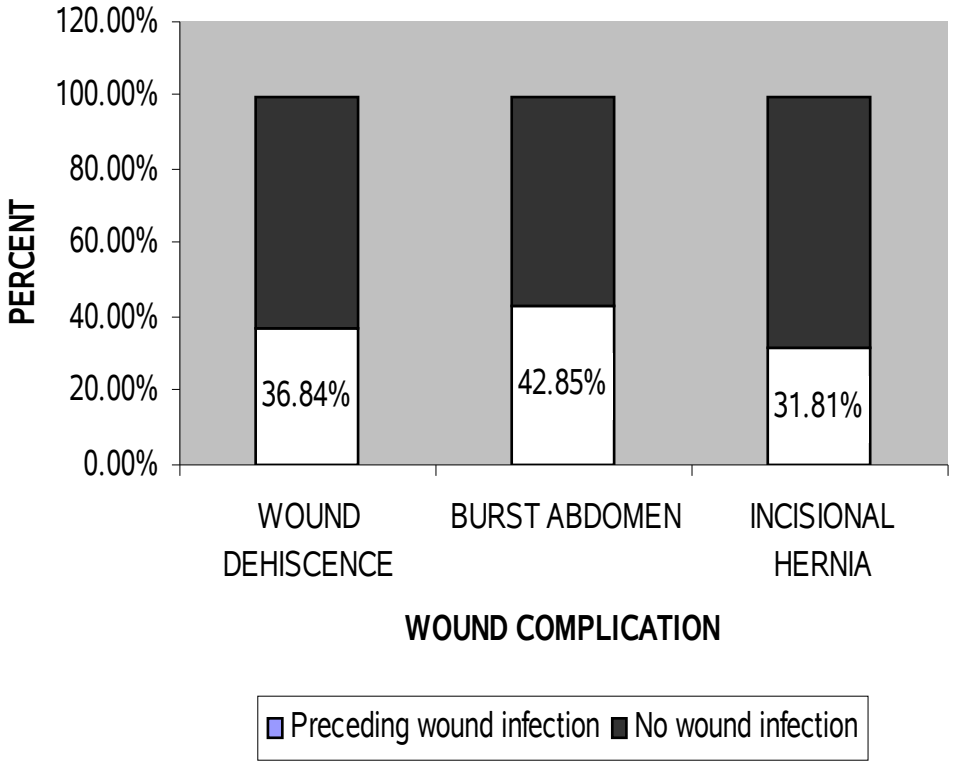
S.NO	CLINICAL VARIABLES		WOUND COMPLICATIONS							
			Wound infection		Wound dehiscence		Burst abdomen		Incisional hernia	
			Yes	No	Yes	No	Yes	No	Yes	No
1.	Diabetes mellitus	Yes	1	10	1	10	1	10	1	10
		No	33	107	18	122	6	134	14	126
	Chi – square		1.22		0.13		0.53		0.009	
2.	Hypertension	Yes	2	7	1	8	1	8	0	9
		No	32	110	18	124	6	136	15	127
	Chi – square		0.001		0.01		0.90		1.05	
3.	Jaundice	Yes	2	9	4	7	2	9	2	9
		No	32	108	15	125	5	135	13	127
	Chi – square		0.12		6.10*		4.92*		0.90	
4.	Renal failure	Yes	4	19	6	17	2	21	2	21
		No	30	98	13	115	5	123	13	115
	Chi – square		0.40		4.49*		1.01		0.04	
5.	Pulmonary disease	Yes	10	34	11	33	6	38	8	36
		No	24	83	8	99	1	106	7	100
	Chi – square		0.002		8.70*		11.37*		4.72*	
6.	Anemia	Yes	0	22	4	18	2	20	1	21
		No	34	95	15	114	5	124	14	115
	Chi – square		7.48*		0.73		1.15		0.83	
7.	Hypoalbuminemia**	Yes	6	35	11	30	6	35	8	33
		No	0	7	1	6	0	7	0	7
	Chi – square		1.17		0.50		1.17		1.63	
8.	Enteric fever	Yes	3	5	3	5	1	7	1	7
		No	31	112	16	127	6	137	14	129
	Chi – square		1.08		4.76*		1.18		0.06	
9.	Heart disease	Yes	0	6	1	5	0	6	0	6
		No	34	111	18	127	7	138	15	130
	Chi – square		1.81		0.09		0.30		0.68	
10.	Nutritional status:									
	Underweight		20	61	11	70	5	76	7	74
	Normal		12	45	7	50	1	56	5	52
	Obese		2	11	1	12	1	12	3	10
	p value		0.71		0.83		0.41		0.25	
11.	Malignancy	Yes	0	6	2	4	0	6	0	6
		No	34	111	17	128	7	138	15	130
	Chi – square		1.81		2.44		0.30		0.68	
12.	Smoker	Yes	11	47	8	50	3	55	4	54
		No	23	70	11	82	4	89	11	82
	Chi – square		0.68		0.12		0.06		0.97	
13.	Alcoholic	Yes	8	33	8	33	1	40	4	37
		No	26	84	11	99	6	104	11	99
	Chi – square		0.29		2.45		0.61		0.002	
14.	Site of perforation:									
	Esophagus		0	0	0	0	0	0	0	0
	Stomach		1	2	1	2	1	2	0	3
	Duodenum		15	71	8	78	3	83	7	79
	Jejunum		2	1	0	3	0	3	1	2
	Ileum		6	11	3	14	2	15	2	15
	Appendix		8	16	2	22	0	24	3	21
	Colon		1	8	4	5	1	8	1	8

	Rectum		0	1	0	1	0	1	0	1
	GB / Biliary tract		1	2	0	3	0	3	0	3
	Others		0	5	1	4	0	5	1	4
	p value		0.22		0.13		0.23		0.88	
15.	Stoma	Yes	1	11	4	8	1	11	1	11
		No	33	106	15	124	6	133	14	125
	Chi – square		1.50		5.10*		0.40		0.03	
16.	SICU	Yes	9	47	13	43	4	52	9	47
		No	25	70	6	89	3	92	6	89
	Chi – square		2.11		9.14*		1.26		3.74	
17.	Mechanical ventilation	Yes	9	46	13	42	4	51	9	46
		No	25	71	6	90	3	93	6	90
	Chi – square		1.87		9.61*		1.36		3.99*	

(*$p < 0.05$, otherwise $p > 0.05$; ** S. albumin checked for only 48 subjects.)

There was an association between anaemia and development of wound infection. There was an association between jaundice, renal failure, pulmonary disease, enteric fever, presence of a stoma, SICU admission, and mechanical ventilation with development of wound dehiscence. There was an association between jaundice and pulmonary disease with development of burst abdomen. There was an association between pulmonary disease and mechanical ventilation with development of incisional hernia.

Figure 8: Prevalence of wound infection in subjects who develop other wound complications



It was seen that wound complications were affected by preceding wound infection. It was found that 36.84% of subjects who developed wound dehiscence had a preceding wound infection (p=0.110). Forty-two point eight five percent of subjects who developed burst abdomen had a preceding wound infection (p=0.187). Thirty-one point eight one percent of the subjects who developed incisional hernia had a preceding wound infection (p=0.018); this was statistically significant.

CHAPTER V

DISCUSSION

The study was intended to compare the efficacy of two suturing techniques in reducing early post-operative complications among patients with generalized peritonitis who underwent midline laparotomy. The study was conducted from subjects who presented to the Christian Medical College and Hospital, Vellore, with generalized peritonitis who underwent midline laparotomy.

The sample consisted of 229 subjects who were operated for generalized peritonitis. Seventy-eight subjects were excluded from the study due to the following reasons: previous midline laparotomy (17 subjects), use of suture material other than no. 1 PDS (5 subjects), non-documentation of suture technique (7 subjects), discharge against medical advice prior to the tenth post-operative day (9 subjects), death of subject prior to the tenth post-operative day (20 subjects), requirement of a re-laparotomy within 10 days for a cause not attributable to a complication of wound closure (13 subjects), and lack of adequate post-operative follow-up (7 subjects). Thus one hundred and fifty-one subjects were included in the study.

The study revealed a spectrum of age distribution among the subjects. The mean age of the subjects enrolled in the study was 40.7 years. The mean age of the subjects in the interrupted and continuous technique arm was 39.4 years and 41.7 years respectively. A majority of the subjects (62.2%) were 45 years of age or younger, while only a few subjects belonged to the elderly category (12.6%) (Figure 1).

There was a male predominance in the subject profile. Males comprised 78.8% of the study population while females a mere 21.2 % (Figure 2).

The average length of hospital stay for the post-operative patients was 11.7 days. The average duration of admission for subjects whose fascia was closed by the interrupted technique was 12.09 days while it was 11.45 days for those closed by the continuous technique. Thus the length of hospital stay was marginally longer for those patients closed by interrupted technique. The reason for this increased post-operative hospital stay in the interrupted group could not be ascertained.

Patients were followed-up in the out-patient department post-operatively to look for any abdominal wound complications. The period of follow-up ranged from 10 days to 17 months with an average follow-up period of 107.3 days. The mean follow-up period for the interrupted group was 123.2 days while it was 96.5 for the continuous group. This time was considered sufficient to detect late wound complications.

There were various clinical variables studied (Table 1). Among the 151 subjects enrolled in the study, 38.4% smoked cigarettes and 27.2% consumed alcohol regularly. Thirty six point four percent of them required post-operative ventilation, 37.1% required peri-operative admission to the intensive care unit, and 29.1% had documented pulmonary disease. In the 48 subjects whose serum albumin was tested, 85.4% of the subjects were detected to have hypoalbuminemia.

More than half of the subjects in the study were underweight (53.6%) (Figure 3). Of these, 8.6% of the subjects were obese. Only 37.7% of the

subjects had an optimal weight. This reflects the prevalence of under-nutrition in the country.

A majority of patients had the primary lesion in the duodenum (57%)(Figure 4). Other significant foci of insult were the appendix (15.9%) and the ileum (11.3%). This revealed that duodenal perforation is the most common cause of generalized peritonitis in the population under study. Measures to detect peptic ulcer disease and prophylactic therapy are advocated to reduce the incidence of duodenal perforation.

The study revealed a preferred choice of suture technique. Surgeons during the period of this study chose the continuous technique more frequently (59.6%) as compared to the interrupted technique (40.4%) (Figure 5). This demonstrates the changing trends in the choice of suture technique. In the past, the use of interrupted technique for fascial approximation was the dictum. With convincing studies proving the contrary,[3, 11,16, 46, 48, 66] surgeons of late have preferred using the continuous technique due to its ease, speed, and providing an acceptable wound security as the interrupted technique.

The distribution of risk factors was equally balanced between the two suturing techniques ($p>0.05$). It was found that a higher percentage of subjects closed by the continuous technique did not have any risk factors (11.1%) as compared to the interrupted technique (6.5%)(Table 2).

Despite the presence of a higher number of risk factors in subjects closed by the interrupted technique, they fared better than those in the continuous arm in each of the post-operative complications studied (Figure 6). These will be discussed in more detail under the following headings:

WOUND INFECTION

The incidence of wound infection was 22.5% (Figure 6). This comprises nearly a quarter of the patients in the study. This is much higher than the experience reported by Krukowski, et al,[7] who reported a 9.8% incidence of wound infection in dirty wounds using PDS. They also recorded a wound infection rate of 15.0% in dirty wounds closed using polypropylene sutures.

Comparing the two techniques, 19.7% of the subjects closed by the interrupted technique developed post-operative wound infection as against 24.4%, where the continuous technique was utilized (Table 3). These figures, although not statistically significant ($p>0.05$), are certainly clinically significant.

A probable cause of such a high incidence of wound infection could be the fact that the wound was exposed to significant intra-abdominal contamination during the operation. Other factors such as malnutrition or advanced sepsis due to delayed presentation to the health care centre may also play a role. These factors are seldom reported in western literature. Preventive measures against developing post-operative wound infection include stringent aseptic precautions and avoidance of tense closure which predisposes to tissue necrosis. Optimal nutrition must be ensured during the peri-operative period to enhance wound healing. Public awareness of preventable disease must be propagated and easy accessibility to essential health care should be provided.

The association of wound infection with the demographic and clinical variables was studied. There was no association between an increasing

age of the subject or gender with the development of wound infection (Table 4). This contradicts the findings of other studies.[40]

Surprisingly, the study revealed that anemia was associated with fewer wound infections (Table 5). Only subjects without anemia developed wound infection ($p<0.05$), while no subject with documented anaemia developed wound infection. This seems contrary to our expectation. A possible explanation was that patients with generalized peritonitis are markedly dehydrated at presentation due to third space fluid loss. This results in a relative hypovolemia resulting in a falsely high hematocrit. Very few subjects had their hematocrit rechecked post-operatively, hence a false value of a high haemocrit. There was no association between wound infection and the other clinical variables studied.

It has been shown that the rate of wound infection can be decreased by minimizing contamination and by leaving the skin and subcutaneous tissue open to heal by secondary intention or delayed primary closure when contamination is unavoidable.[27]

WOUND DEHISCENCE

The incidence of wound dehiscence was 12.6% (Figure 6). This is markedly higher than 1% to 3% as reported by Campbell et al[35] and McFadden and Peacock.[36] A plausible explanation for this discrepency could be that the wounds described in previous studies were general figures comprising (1) clean wounds- which included operations in which the alimentary tract was not entered; (2) clean-contaminated wounds- which included abdominal incisions through which the gastrointestinal tract was opened after proper pre-operative preparation; or (3) contaminated

and dirty wounds- which included abdominal incisions through which an unprepared gastrointestinal tract was opened, or operations for intra-abdominal abscesses or perforated viscera.[40] The wounds in this study were all contaminated wounds, which predisposed the subject to develop wound infection.

This study revealed that 36.84% of the patients who developed wound dehiscence were earlier detected to have wound infection (Figure 8). This is higher than that the 10%-15% reported by Donaldson, et al.[50] Wound infection has been reported to be an independent risk factor for developing wound dehiscence.[27]

The incidence of wound dehiscence in the interrupted and continuous technique was 8.2% and 15.6% respectively (Table 3). This revealed nearly a double risk of developing a wound dehiscence while closing the fascia with a continuous technique as compared to the interrupted technique. The possibility of the suture breaking or the knot cutting through tissue may be responsible for this difference, although documentary proof was unavailable. The abdomen in generalized peritonitis is tense. Post-operatively, the ileus usually persists and the abdomen is under tension. Thus knot security may be compromised under these circumstances resulting in a wound dehiscence.

The association between wound dehiscence with the demographic and clinical variables was assessed. There was no association between an increasing age or gender with the development of wound dehiscence (Table 4). This finding contradicts those of previous studies.[27]

Jaundice, renal failure, and enteric fever were significant risk factors for development of wound dehiscence (Table 5). This may be attributed to the poor wound healing associated with the immunocompromised state. This may lead to the suture cutting through the tissue and pulling out resulting in disruption, as the redundant suture is unable to generate the required tension for wound approximation, resulting in a wound dehiscence.

Pulmonary disease was found to be an independent risk factor in the development of wound dehiscence (Table 5). This confirms the observation of Riou et al[27] and Niggebrugge et al.[40] Predisposing factors for developing post-operative pulmonary complications include chronic heart or lung disease, cigarette smoking, malnutrition, renal failure, and emergency abdominal surgery. The propensity for fascial disruption is due to an increased intra-abdominal pressure experienced by the coughing patient during early wound healing.[27] Tobacco abstinence for several weeks prior to surgery, optimization with bronchodilators peri-operatively, incentive spirometry and post-operative pulmonary toilet are some of the measures that can be undertaken to minimize this risk factor. Obviously, not all these preventive measures can be adhered to in an emergency situation.

There was a significant association between the placement of a stoma and development of wound dehiscence (Table 5). During the study all stomas were trephined through healthy skin separate from the skin incision. The cause of this association could not be ascertained.

Patients who were admitted peri-operatively in the surgical intensive care unit, especially those requiring mechanical ventilation were more prone to develop wound dehiscence (Table 5). This may be due to the increased

intra-abdominal pressure caused during mechanical ventilation, predisposing to wound blow-out. Admission into an intensive care unit and mechanical ventilation also predisposes to development of nosocomial infections and pulmonary complications.

BURST ABDOMEN

The incidence of burst abdomen was 4.6% (Figure 6). This figure is higher than that reported by Bucknall et al[15], who reported the incidence to be less than 1% after adoption of the mass closure technique. The interrupted technique recorded an incidence of 1.6% of burst abdomen, as against the 6.7% who developed it after closure with the continuous technique (Table 3). This association was clinically significant but not statistically significant.

Burst abdomen is usually due to the suture cutting through the tissue. This may be due to a defective technique where the fascia was closed under tension. Another plausible explanation for this finding may be attributed to a thinner fascial aponeurosis where the suture holding strength is low. This may be due to geographical variations as well as the high rate of under-nutrition, which may cause thinning of the fascia. Wound infection also predisposes to development of burst abdomen. In this study 42.85% of subjects who developed burst abdomen had a preceding wound infection (Figure 8).

The association between demographic variables and development of burst abdomen was studied. An increasing age predisposed to development of burst abdomen, though it was not statistically significant (p=0.08)(Table 4). Studies have shown age to be an independent risk factor in the

development of wound disruption.[27] There was no association between gender and development of burst abdomen.

Jaundice and pulmonary disease was found to be associated with burst abdomen (Table 5). Their pathophysiology has already been elucidated earlier. As both wound dehiscence and burst abdomen are part of the same spectrum of wound disruption, the above findings are expected. Burst abdomen has been associated with a high mortality rate, exceeding 35%. Hence preventable or treatable risk factors assume great significance in management of a burst abdomen.

INCISIONAL HERNIA

The study recorded the post-operative incidence of incisional hernia to be 9.9% (Figure 6). This is at the upper limit of 3% to 9% that has been reported by Irvin,[42] Leaper,[20] and Cameron.[4] Pollock et al[21] and Bucknall et al[15] reported an incidence of about 11% in their findings. There was an 8.2% incidence of incisional hernia in the interrupted arm while there was 11.1% incidence in the continuous arm (Table 3). This difference was not statistically significant ($p>0.05$). Further incision hernia could have occurred after conclusion of the study, but studies have shown that most incisional hernia occur within 3 months, but may only be discovered at a later date.[46,47]

The high incidence of incisional hernia could be attributed to the high rate of post-operative wound infection recorded. It was found that 31.81% of subjects who developed incisional hernia had a preceding wound infection (Figure 8). The part played by wound sepsis is important, as this is the major avoidable cause of wound failure. Forty-eight percent of patients

with incisional hernia had been reported in another study to have a preceding wound infection.[15] Fischer and Turner in 1974 found that 88% of patients with incisional hernia requiring repair had previously documented a wound infection.[44] Pollock, Greenall, and Evans,[21] reporting on a trial of single-layer mass closure in 1979, concluded that the incidence of incisional hernia wound be reduced by the elimination of wound sepsis. This finding was also confirmed in a series by Bucknall et al.[15]

Pulmonary disease and peri-operative mechanical ventilation were associated with a higher incidence of incisional hernia (Table 5). This re-emphasizes the need for early addressal and correction of peri-operative pulmonary complications. There was no statistical association obtained between the other demographic and clinical variables with the development of incisional hernia (Tables 4 & 5). The main causes of incisional herniation are technical inadequacy and wound infection as stated by Ausobsky et al.[43] Pulmonary complications also predispose to development of incisional hernia. The results of this study prove this fact.

Thus we see through this study that the post-operative challenge to wound strength is largely dependent on suture technique, wound infection, and various risk factors. Many factors may be out of the surgeons control; but the choice of suture and technique of fascial closure places the onus of prevention of post-operative wound complications irrevocably on the surgeon.

CHAPTER VI

SUMMARY AND RECOMMENDATIONS

The best method of wound closure is one that maintains tensile strength throughout the healing process with good tissue approximation, does not promote wound infection or inflammation, is well tolerated by patients, and is technically simple and expedient.[71] Any method of abdominal wall closure is usually judged in the short-term by the number of wound infections, wound dehiscence rates, and frequency of burst abdomen. The long-term complication can be assessed by the rate of development of incisional hernia.

The purpose of the study was to record the wound complications after midline laparotomy in generalized peritonitis and the current trends in the choice of technique of fascial closure. A descriptive design was used to conduct the study. The purpose of the design was to compare and document the post-operative complications arising with the use of two suturing techniques. The sample size was 151. It was a prospective non-randomized study. Objective data was collected from the subjects with the help of a questionnaire. The data was then analyzed using appropriate statistical techniques.

SALIENT FINDINGS:

- There was a male predominance in the subject profile. Males comprised 78.8% of the study population (Figure 2).

- Duodenal perforation was the most common cause of generalized peritonitis in the population under study (Figure 4).

- Majority of the fascia (59.6%) were closed using continuous technique (Figure 5), demonstrating the growing popularity of this technique.

- Patients with interrupted closure had a lower incidence of wound infection, wound dehiscence, burst abdomen, and incision hernia as compared to those closed by the continuous technique. The difference was not statistically significant.

- Jaundice, renal failure, enteric fever, and presence of stoma were associated with an increased risk of wound disruption (Table 5).

- Pulmonary disease was associated with increased post-operative wound dehiscence, burst abdomen, and development of incisional hernia (Table 5).

- Admission to the surgical intensive care unit and mechanical ventilation were associated with an increased risk of development of post-operative wound disruption and subsequent incisional hernia (Table 5).

- As it was found that 31.81% of subjects who developed incisional hernia had a preceding wound infection, the incidence of incisional hernia would be reduced by the elimination of wound sepsis.

IMPLICATIONS OF THE STUDY:

Surgical practice:

Surgery is an ever-evolving field. The novel discoveries of today become the obsolete myths of tomorrow. Change can only be implemented if there is consistency and universality in finding. The practical value of any method of abdominal wound closure can be judged only when it is used in unselected patients by all surgeons who close abdominal wounds, irrespective of their degree of training. The above study provides convincing proof that the interrupted technique of fascial closure is superior to the continuous technique in prevention of both early and late wound complications in a contaminated wound.

Education:

Many of the risk factors predisposing an individual to develop generalized peritonitis and subsequent wound complications are preventable. Its prevention necessitates possible lifestyle modifications or appropriate medications. The onus of educating the public on the primary prophylaxis of generalized peritonitis rests upon the medical practitioner.

Every practicing general surgeon faces the daunting task of performing a laparotomy. Abdominal fascial closure is often regarded as mundane and insignificant. The secret of successful abdominal closure lies in good surgical technique. It is the duty of every aspiring surgeon to identify and practice correct surgical technique. It is the moral responsibility of the senior surgeon to educate his apprentice in correct surgical technique.

The study has aspired to observe and record wound complications after midline laparotomy incisions in the hope of spurring renewed interest in abdominal closure. It has emphasized the need for proper surgical technique and suggests the adoption/continuation of the interrupted technique for fascial closure in generalized peritonitis.

Research:

One cannot begin to investigate something unless one can measure it. This study can be a basis for further research on the efficacy of surgical technique in preventing post-operative wound complications.

RECOMMENDATIONS FOR FURTHER RESEARCH

- Larger randomized trials can be done to determine a statistically significant association between surgical technique and the incidence of post-operative complications.

- The association of hypoalbuminemia and under-nutrition with the development of wound complications in generalized peritonitis could be analyzed using more appropriate instruments.

- The complications of post-operative wound sinus formation and wound pain were not addressed in this study. Further studies could be done to study their association with suture technique.

CONCLUSION

The ideal method of abdominal wound closure has not been discovered. The ideal method should be technically so simple that the results are as good in the hands of the trainee as in those of the surgical master; it should be free from the post-operative wound complications; it should be comfortable to the patient; and it should leave a reasonable aesthetic scar.[15]

The interrupted technique of abdominal fascial closure is advocated in decreasing both early and late post-operative wound complications in a contaminated wound. Various modifiable risk factors have been described to decrease the rate of development of post-operative wound complications. Although this study provides insight on proper surgical technique; however, much remains to be unraveled in the Pandora's Box.

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APPENDIX A: PROFORMA

PROFORMA
RECTUS CLOSURE IN PERITONITIS

Department of General Surgery, CMC, Vellore

Serial No: Hospital No:

Name: Age: Sex:

DOA: DOSx: DOD:

Condition at discharge : Alive / Expired

Co- morbidities:

Diabetes Mellitus : Yes / No

RBS: mg%

AC: mg%

PC: mg%

Hypertension : Yes / No

Jaundice : Yes / No

T. Bilirubin: mg%

D. Bilirubin: mg%

Renal Failure : Yes / No

S. Creatinine: mg%

S. Urea: mg%

Pulmonary Disease : Yes / No

Anemia : Yes / No

Hb / PCV: gm%

Hypoalbuminemia : Yes / No

S. Albumin: mg%

Enteric Fever : Yes / No

Heart Disease : Yes / No

Nutritional Status : Underweight / Normal / Obese

Weight - kg

Height - m

BMI -

Malignant Disease : Yes / No

Lifestyle Factors : Smoker – Yes / No

Alcoholic – Yes / No

Diagnosis :

Site of perforation: Esophagus / Stomach / Duodenum / Jejunum / Ileum / Appendix /

Colon / Rectum / Gall bladder or biliary tract / Others

Surgery Performed :

Stoma : Yes / No

Technique of closure : Interrupted / Continuous

Post-op SICU Admission : Yes / No

If yes, duration :

Mechanical Ventilation : Yes / No

If yes, duration :

Post-op abdominal wall complication(s) :

- Wound infection : Yes / No
- Wound dehiscence : Yes / No
- Burst abdomen : Yes / No
- Incisional hernia : Yes / No

Re-laparotomy done : Yes / No

- Due to abdominal wall complication: Yes / No
- If yes, date of surgery :
- Surgery performed :

Other complications :

Post-op outpatient follow-up :

- No. of visits :
- Date of last visit :
- Period of follow-up :

APPENDIX B: MASTER TABLE

THESIS ABSTRACT

TOPIC:

A study to compare the efficacy of two suturing techniques in reducing the development of post-operative complications among patients with generalized peritonitis who underwent midline laparotomy while admitted in the General Surgical Units of Christian Medical College, Vellore.

INVESTIGATOR:

Dr. Vivek Samuel Gaikwad

GUIDE:

Dr. V. Sitaram

UNIVERSITY:

The Tamil Nadu Dr. M G R University, Chennai.

INTRODUCTION:

Despite advances in surgical technique and materials, abdominal fascial closure has remained a procedure that often reflects a surgeon's preference with a reliance on anecdotal experience. The ideal technique, although suggested by surgical literature has not been uniformly accepted. A sound suture technique should hold good in all circumstances, i.e., both

in clean and contaminated wounds. The efficacy of a particular technique may be measured by the incidence of early and late wound complications. Early complications include wound infection, wound dehiscence, and burst abdomen; whereas late complications include incisional hernia, suture sinus, and wound pain.

This study seeks to allocate patients into two groups: one, in which the continuous technique is used for the closure of the linea alba, and the other in which an interrupted technique is used. The study aspires to observe and record wound complications after midline laparotomy incisions in the hope of spurring renewed interest in abdominal closure, and possibly gathering evidence that warrants change in the current trend, or evidence encouraging the ongoing practice.

AIMS AND OBJECTIVES:

1. To assess the incidence of post-operative complications among patients with generalized peritonitis undergoing midline laparotomy.
2. To determine the association between the suturing techniques and post-operative complications and to see if interrupted closure led to fewer post-operative complications.
3. To determine the association of the post-operative complications with the demographic and clinical variables.

MATERIALS AND METHODS:

A descriptive design was used to conduct the study. The purpose of the design was to compare and document the post-operative complications arising with the use of two suturing techniques. The suture technique was based on the discretion of the operating surgeon. It was a prospective non-randomised study where all consecutive subjects who fulfilled the inclusion criteria were incorporated. The study comprised of 151 subjects.

The data was analysed as follows:

1. Post-operative complications were presented using descriptive statistics.
2. Test for proportions was used to compare the post-operative complications in each group.
3. Chi-square analysis was used to determine the association between the suturing technique used and the post-operative complications.
4. The association of post-operative complications with the demographic and clinical variables was assessed using chi-square analysis.

SUMMARY:

The salient findings of the study are as follows:

- There was a male predominance in the subject profile. Males comprised 78.8% of the study population.
- Duodenal perforation was the most common cause of generalized peritonitis in the population under study.
- Majority of the fascia (59.6%) were closed using continuous technique, demonstrating the growing popularity of this technique.

- Patients with interrupted closure had a lower incidence of wound infection, wound dehiscence, burst abdomen, and incision hernia as compared to those closed by the continuous technique. The difference was not statistically significant.
- Jaundice, renal failure, enteric fever, and presence of stoma were associated with an increased risk of wound disruption.
- Pulmonary disease was associated with increased post-operative wound dehiscence, burst abdomen, and development of incisional hernia.
- Admission to the surgical intensive care unit and mechanical ventilation are associated with an increased risk of development of post-operative wound disruption and subsequent incisional hernia.
- As it was found that 31.81% of subjects who developed incisional hernia had a preceding wound infection, the incidence of incisional hernia would be reduced by the elimination of wound sepsis.

CONCLUSION:

This study shows that the interrupted technique of fascial closure is superior to the continuous technique in prevention of both early and late wound complications in a contaminated wound. Further larger studies are indicated to demonstrate statistical significance. Various modifiable risk factors have been described to decrease the rate of development of post-operative wound complications.