ISSN 2073-9990 East Cent. Afr. J. surg. (Online)

Surgical Measures to Reduce Infection in Open Colorectal Surgery

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Post-operative infection is an important complication of colorectal surgery and continued efforts are needed to minimize the risk of infection. A better understanding about susceptibility to infections will explain why a patient with minimal bacterial contamination at surgery may develop a pelvic abscess whereas another patient with massive faecal contamination after stercoral perforation of the colon may not develop infective complications. The most important factor in determining post-operative sepsis is the presence of viable organisms in the surgical field prior to wound closure. This review focuses on aspects of operative techniques that reduce infection in colorectal surgery. Despite antibiotic prophylaxis and therapy, the inadequate attention to technique and incorrect surgical decision making (i.e. surgeon-related factor) remain the single most important factor that can influence the morbidity and mortality from sepsis in colorectal surgery.

Introduction

Colorectal surgery is associated with a high sepsis rate which may lead to serious complications including death. Intra abdominal sepsis in colorectal surgery can occur either spontaneously (at time of the colorectal catastrophe) e.g. acute appendicitis or perforated diverticular disease or postoperatively (late) as a complication of surgery such as wound or deep abdominal infection. Postoperative sepsis is usually caused by anastomotic breakdown or a failure to eradicate infection at the original laparotomy due to inadequate elimination of sepsis, an unrecognized perforation or an infected haematoma[1,2,3] . The mortality from postoperative intra-abdominal sepsis is greater than 50% and the mortality increases with each operation to treat recurrent or persistent sepsis. Therefore, the best opportunity to eradicate infection is the first operation[1,4].
Sepsis prevention in abdominal surgery depends upon:

1. The degree of contamination of the peritoneal cavity,
2. The preoperative status of the patient, and
3. Surgical technique.[1,3-5]

In emergency colorectal surgery, for example colonic perforation, there is normally contamination of the peritoneal cavity and the mortality is greater than 50% despite systemic antibiotic therapy. In elective (planned) colorectal surgery generally considered as being 'clean-contaminated' the mortality is less than 1%[1,3]. The normal gut micro flora may cause postoperative infection when allowed to spread from their normal site. Many older patients undergo relatively more complex and contaminated operations, and a greater proportion of elderly patients have major emergency procedures.

The most important prognostic factors in emergency colorectal surgery are the preoperative status related to age and faecal peritonitis. Together the mortality is greater than 60%[3]. Faecal peritonitis, because of bacteria load produces a rapid and profound systemic inflammatory response syndrome (SIRS) with consequent multiple organ failure to which the elderly patient more easily succumbs[4,5,7,8]. A major factor predisposing to surgical site infection and delayed wound healing is immunodeficiency. Although surgical procedures can be safe and effective therapeutic modalities, the benefits of resolution of symptoms must be balanced against this risk. Aggressive surgical interventions must be undertaken with caution[9]. In the current highly active antiretroviral therapy (HAART) era, there is an improved surgical outcome as patients have an improved general resistance to infection and are nutritional better to withstand abdominal surgery. This is

ISSN 2073-9990 East Cent. Afr. J. surg. (Online)

supported by good preoperative and anaesthetic care along with the preventive measures against occupational HIV transmission[9-11].

According to the 'recommendations for best practice' from the Association of coloproctology of UK and Ireland, and the Scottish intercollegiate Guidelines Network (2001), surgeons should audit the outcome of their colorectal surgery. They should expect to achieve an operative mortality of less than 20% for emergency surgery and 5% for elective surgery for cancer; an overall leak rate below 4% for colonic resection, and wound infection rates after surgery for colorectal cancer should be less than 10%[12]. Prophylactic antibiotic therapy is inferior to good surgical and aseptic technique.

The **aim** of this paper is to review and ascertain the rationale for the surgical (operative) measures taken in colorectal surgery to reduce post operative intra-abdominal sepsis and surgical site infection.

Methods

Electronic searches of the Medline (PubMed) database, Cochrane library, and science citation index were performed to identify original published studies on sepsis in abdominal/colorectal surgery and prevention. Relevant articles were searched from relevant chapters in specialized texts and all included.

The Intraoperative Setting

Intraoperative factors predisposing to infection include hypoxia, hypothermia, poor soft tissue handling, haematoma formation, a break in aseptic technique, poor wound closure and failure to remove devitalized tissues, or to irrigate appropriately[5,6]. Surgical techniques are carried out under aseptic conditions. Asepsis involves the use of sterilized articles in contact with patient, antiseptically scrubbed hands covered with sterile gloves and antiseptically prepared skin. Surgical site infection is the third commonest nosocomial infection after urinary and respiratory tract infections[1,2]. Skin preparation eliminates exogenous skin organisms which are an important source of post operative wound infection with substantial morbidity and mortality[2]. The World health organization(WHO) in 1981 suggested antiseptic shower before operation which is still applied in many European countries, but a recent meta-analysis of preoperative antiseptic bathing have showed no evidence in its prevention of surgical site infection[13]. Shaving of the operative site traumatizes the skin and promotes colonization with microorganisms with a 6% post-operative wound infection rate. Use of depilatory cream or clipping with specially designed clippers is associated with lower infection rates of 0.6% and 1.7% respectively[2].

Face mask have been traditionally used since the early 20th century but its usefulness is not evidence- based. There has been no prospective randomized trial to show its benefit[14]. Few bacteria are dispersed from the mouth during normal breathing and quiet conversations, and it is argued that for general abdominal operations masks are not required.[6] Antibiotic prophylaxis can reduce the wound sepsis rates if the appropriate antibiotics are suitably administered perioperatively as it provides a drug tissue concentration at the time of bacteria contamination during the surgical procedure sufficient to prevent bacterial growth[15]. The *surgical incision* in elective (planned) surgery simply requires it to be adequate but a midline incision is required in emergency surgery. A midline incision is simple and rapid, can be extended (providing access to all quadrants of the abdomen), avascular, entails minimal tissue trauma, easily repaired with mass closure, and does not prejudice the placement of a stoma[3,20,24]. The importance of access is corroborated by the finding of a 40% sepsis rate using a small incision to remove a perforated appendix[1]. Restricted exposure and access lead to inadequate surgery with incomplete peritoneal toilet and lavage and limited colonic mobilization.

Wound protection: 40% of dirty / contaminated abdominal surgery have wound infections despite antibiotic therapy[1-3]. Contamination of the parietes cannot be avoided completely but the

ISSN 2073-9990 East Cent. Afr. J. surg. (Online)

degree of soiling (for instance by intestinal content) can be minimized. Preventive measures include mechanical barriers (absorbent wound towels, plastic ring drapes) and the use of an antiseptic- soaked gauze around a site of potential contamination, for example during anastomosis formation[16,17]. However, there is no statistical evidence that the incidence of wound infection as distinct from contamination is thereby reduced[6]. Bacterial multiplication occurs in the moist conditions under adhesive drapes, therefore may be useful to hold other drapes and equipment in position, but is not justifiable microbiologically. Contamination of the abdominal parietes may be minimized by elevating the abdominal wall and aspirating pus and contaminated peritoneal fluid via a small incision in the peritoneum before it percolates over and inoculates the wound[3].

Bacteriological examination of pus swabbed or collected from septic/ infected foci may indicate the aerobic or anaerobic organisms involved and their sensitivities. Peri-operative antibiotics will suffice if the culture is negative.[15] If heavily contaminated post-operative (therapeutic dose) antibiotics is required.[5]

Peritoneal debridement may be required in the septic abdomen. It should not be very radical as iatrogenic injuries to bowel may occur. Loose fluid, non-viable tissue and loose debris are aspirated or mopped out. Adherent fibrin is removed when possible, but not if this traumatizes the underlying viscera. Gentle tissue handling prevents necrosis. Tissue that is bruised or well localized ischaemia develops is more likely to become infected. Extensive dissection to the septic focus is avoided[3,6].

Peritoneal lavage is done as soon as the abdomen is opened if gross peritoneal contamination and repeated until a clear return prior to closure[18]. Warm normal saline is usually used. Clinical trials have not shown a decreased mortality from using antiseptic solution. Instead antiseptic solutions for example Iodine can cause adhesions and can trigger an allergic reaction[6]. There is evidence that antibiotic lavage (e.g. tetracycline 1mg/ml) may supplement the mechanical saline effect. It has been shown to abolish the risk of bacteria dissemination, has low toxicity, reduces incidence of wound and intraperitoneal infection, permits safe radical surgery, reduces the requirement for post operative antibiotics and abolishes growth of bacteria in peritoneal fluid[3,18]. Difficulty obtaining a suitable parenteral preparation of tetracycline has forced a change to cefotaxime as the lavage agent (1mg/ml, 0.9% saline) which had been use for many years in paediatric practice[8]. However, antibiotic lavage may also have the problem of causing adhesions and it is of concern if 'antibiotic' lavage is actually needed in the presence of systemic broad spectrum antibiotics[5,15].

Intestinal decompression is required in severe intestinal obstruction. This greatly improves access and reduce risk of intestinal perforation[19,20]. This can be done by either suction aspiration of colonic gas using a 22g i/v cannula through the taenia or by Foley catheter decompression of large and small bowel. The latter is done by passing a Foley catheter via an enterotomy in the terminal ileum and pushed past the ileocaecal valve to anchor with its balloon in the caecum. It could also be used for colonic lavage[21]. Many surgeons carry out on-table colonic lavage of an obstructed left colon during emergency left- sided resection prior to anastomosis for fear of faecal soiling or stercoral perforation[19,21]. As long as faecal soiling is technically avoided or minimized there is usually no need nor time for on- table colonic lavage especially in these ill patients[20].

Surgical Technique

In colorectal surgery adequate mobilization of the colon is essential so that there is redundant gut on at least one side of the anastomosis, so preventing tension at the suture line. Frequently, the inferior mesenteric vein also needs to be divided at the inferior border of the pancreas to gain further length[23-25]. A selective approach to mobilization is most likely to benefit patients with a high and difficult splenic flexure. The tumour location and the patient anatomy should play a major role in determining the surgeon's decision[26]. The objectives of simply avoiding tension and maintaining a good blood supply are more important. *Careful handling of the cut ends of the bowel*

ISSN 2073-9990 East Cent. Afr. J. surg. (Online)

and gentle tying of anastomotic sutures so that the bowel ends are just approximated help to prevent tension and tissue necrosis. Overzealous tidying of bowel ends may devascularize the bowel ends[27,28]. *Maintenance of gut perfusion* by preventing hypoxia and hypotension to which the large bowel is particularly sensitive is also important. When preparing the bowel for anastomosis, the bowel is transected obliquely and slightly backwards towards the antimesenteric border as the blood vessels run in that direction; otherwise an ischaemic tip may occur[27,30]. Ensuring visible pulsation at the proximal anastomotic segment or visible bleeding at the cut ends is useful[29]. There are numerous variations in *anastomotic technique*. Although no definite recommendations can be made regarding anastomotic technique, the interrupted serosubmucosal method is adaptable to all colonic anastomoses, and has the lowest reported leak rate of 0.5-3%[12,35].

Goligher had documented that most rectal anastomotic disruption occurs in the posterior aspect of the anastomosis.[28] Foster concluded that the poor blood supply to the posterior midline of the rectum leads to increased ischaemia and, therefore increased disruption of rectal anastomoses.[33] This is the reason why some authors prefer full-thickness interrupted vertical mattress suturing of the posterior wall of a colorectal anastomosis, approximating and inverting the mucosa intraluminally to act as a mucosal seal but a simple extramucosal suturing of the anterior layer.[23,24,31] However, many surgeons currently opt to use the circular stapling end to end anastomosis (EEA) device as it is easier and quicker to perform.[23-25,37] There is easier access with less trauma to the anal sphincter. It is preferred for patients in whom there may be tension in the mesentery on bringing the reservoir down to the anal level. After removal of the staple gun, the integrity of the anastomosis can be checked by direct palpation if within reach, and the mucosal doughnuts also checked for integrity.[37] The majority of randomized prospective studies found no difference in leak rate between stapled and hand-sewn anastomosis but more stenosis in the former.[38]

Intraoperative detection of anastomotic dehiscence

Early detection of a leaking colorectal anastomosis is essential to prevent mortality and the earliest time to identify a leaking anastomosis is at its formation. Several studies advocate intraoperative air testing as a means of identifying the lack of integrity of a colorectal anastomosis.[40,41] Beard et al found significantly higher clinical (4% vs 14%) and radiological (11% vs 29%) leak rates in patients who were not air tested.[41] In this test, the patient's pelvis is filled with saline; the bowel proximal to the anastomosis is occluded, usually with a non crushing bowel clamp; and then air is insufflated usually with a proctoscope, through the anus, distending the colon and the anastomosis. The surgeon then checks for leakage of air through the anastomosis, which manifests itself as bubbles in the pelvic irrigation. When the precise site of leakage is identified, it can be repaired with Lembert sutures. If repair cannot be adequately done, a defunctioning stoma will prevent the sepsis that may develop from the leak.

Avoidance of anastomosis

As postoperative mortality from anastomotic leak is high, anastomosis is avoided when the risks of leakage are high. Anastomosis is avoided after emergency (l) sided colonic resection in the presence of major contamination and abscess formation. This is compounded by its tenuous blood supply.[1,3,42] In these cases a Hartmann's procedure (resection of the rectal/ distal colon lesion, oversewing or exteriorization of the rectal stump and formation of a left iliac fossa colostomy) is the safest option. [3,43] However, it brings its own peculiar set of problems. A left iliac fossa colostomy brought out under tension can result in complications as problematic as poor anastomosis. Breakdown of the suture line on the rectal stump can lead to significant peritonitis particularly if the intraperitoneal portion is long and packed with stool. Reversal of Hartmann's is a difficult procedure with increased complications including anastomotic leakage. Thus 30-50% of Hartmann's procedures are never actually reversed.[1-3,25] The recent systematic review comparing outcomes following primary resection and anastomosis (PRA) and Hartmann's procedure in emergency surgery for acute diverticulitis confirms the above observations.[46] The mortality after

ISSN 2073-9990 East Cent. Afr. J. surg. (Online)

PRA was 7.4% and Hartmann's 15.6% and these results have not improved over the intervening 25yrs.[45]

Single stage procedure

Corroborated by the above observations and the fact that advocates of primary colon anastomosis achieve leak rates of less than 7%, the role of PRA during an emergency admission is increasingly being promoted even in the presence of diffuse or faecal peritonitis.[20,22,45] It however remains controversial and should be used selectively when circumstances are favourable. The increasing use of primary anastomosis probably reflects improvement in perioperative care which anticipate and treat cardiovascular instability and hypoxia promptly, promoting anastomotic healing in the critical first 48hrs after surgery[5,8] .

The impact of faecal diversion

A covering defunctioning stoma is required if there is (a) gross contamination, (b) for a high velocity missile injury, (c) multiple injuries, (d) hypotension. [1-7] A loop ileostomy is favoured to a loop transverse colostomy in defunctioning a distal colonic anastomosis especially because following its closure the blood supply to the distal colon is not compromised, whereas, the marginal artery is potentially at risk when the latter is closed or resected at the time of closure.[23-25]

The ileostomy can as well cause morbidity, both in its formation and in its closure accounting for 20% of complications. It is often difficult to get a loop of small bowel to reach the anterior abdominal wall after ileal pouch surgery where the small bowel mesentery is pulled taut across the posterior abdominal wall to allow the ileal pouch to reach the anus.[43]

Proximal faecal diversion does not decrease the rate of anastomotic leak, but has been shown to decrease mortality and septic complications in those patients who do leak.[1] If an elective diversion is performed, stoma closure is performed 3 months after the initial procedure when closure is technically easier due to biological adhesiolysis. Patients who undergo emergent diversion for anastomotic leak have their stomas closed at some point after 3 months[22]. Some patients with significant prior co-morbidity or who may have been so debilitated by the postoperative complications will not be candidates for closure[30]. Residual pelvic inflammation or scarring from severe anastomotic leak may render the ultimate closure of a proximal colostomy not technically possible or desirable. Prior to closure of any diverting stoma, a water soluble contrast should document healing of the anastomosis[37]. A flexible endoscopic examination will also ensure that a stricture or stenosis has not formed during the period of diversion. If present, the stricture at the colorectal anastomosis must be treated by either endoscopic dilatation or resection. If a proximal anastomosis is performed with a distal stricture in place, the proximal anastomosis is at significantly increased risk of leak[28].

Abdominal drainage

It is generally futile to attempt to drain an anastomosis or the general peritoneal cavity as an enterocutaneous fistula may ensue[1]. The evidence is that drains may cause more problems than they solve if they are placed 'just in case' of a leak. The adhesions that occur in the healing process of the anastomosis or general peritoneal cavity will attract the peritoneal drain (foreign body) which may physically damage the anastomosis or small bowel. Secondly, the anastomosis needs to gain some extra blood supply, which it does by forming adhesions to adjacent vascular structures. If a piece of corrugated plastic is placed beside an anastomosis it will be unable to do this and a leak will be encouraged. The only exceptions to this are where the anastomosis is not watertight, such as with bile and urine, and a collection will interfere with healing[51]. Most surgeons are wary of the potential danger suction may do to an anastomosis. Redivac drains are deliberately not placed in the vicinity of anastomoses and are removed after 48hrs[28,30].

ISSN 2073-9990 East Cent. Afr. J. surg. (Online)

Drains have been shown to make no difference in the rate of anastomotic dehiscence[1,47]. They can indeed mislead the surgeon as they easily get blocked. It is preferable for an anastomotic leak to reveal itself so that it can be managed accordingly. If there is no drain you can tell if an anastomosis has leaked by clinical signs backed by a water-soluble contrast study- the definitive investigation to determine if there is a leak[1]. Vigilance in the post-operative period is the key, and to remember that anastomotic failure can occur. Large bore drains are useful in sepsis and a modified Foley catheter for continuous irrigation of especially perineal wounds[49]. Saline irrigation is also sometimes infused through presacral drains to prevent large clots from forming and occluding the drains, thereby increasing their efficiency[47]. Transabdominal closed-suction drainage of pelvis following abdominoperineal resection for malignancy is more effective than perineal drainage with respect to perineal wound healing and convenience to the patient[50]. A perineally-placed drain almost always produces local sepsis and delayed healing of the perineal wound[48-50].

Closure of the abdomen

Following saline/ antibiotic lavage, the contaminated drapes are discarded and instruments and gloves are changed. Optimum closure technique employs mass closure of the abdominal wall with a continuous monofilament suture which must persist in the wound for at least 6 months). Bites are placed at least 1cm from the wound edge and 1 cm apart taking the subcutaneous fat, anterior and posterior rectus sheath and peritoneum together[51,52]. Incisional hernias or complete wound dehiscence ('burst abdomen') rarely occur using this biomechanically efficient mass closure technique with Jenkin's rule (4:1 ratio of length of suture to wound) as compared to interrupted suturing[51]. However, wound dehiscence may still be influenced by the premorbid state of the patient (malnutrition, sepsis, inoperable malignancy, chronic obstructive airway disease , morbid obesity, jaundice etc) and post operative wound infection[53]. Mass closure technique is nevertheless still effective for a 'burst abdomen and dehiscence rarely recurs[51].

Further lavage of the subcutaneous space with saline or antiseptic/ antibiotic (cefotaxime) precedes primary skin closure. This strategy even in 'dirty' surgery, is associated with low wound infection rate and routine delayed primary closure of contaminated wounds at first laparotomy is not necessary in civilian practice[3,8]. Despite good antimicrobial coverage, the incidence of postoperative wound infection in elective colorectal surgery remains in the range of 5 - 10%[1]. Systemic antibiotic prophylaxis reduces intra-operative contamination. Local antibiotic delivery to the wound site may help to reduce this rate even further. The implantation of a reabsorbable gentamicin-containing collagen sponge at the operation site in elective colorectal surgery can reduce the incidence of postoperative wound infection when used in association with systemic metronidazole prophylaxis active against anaerobes[54]. If grossly contaminated the subcutaneous layer and skin may be left open. A small bore suction drain in the subcutaneous space may be useful in preventing wound infection especially in the obese[3,6]. Following abdominal wound closure and dressing, the gauze- covered stoma if created is completed by mucocutaneous interrupted sutures and a stoma bag applied[3,23-25].

Conclusion

Intra abdominal sepsis is one of the most challenging situations in surgery. Sepsis and mortality in surgery is obviously commoner in emergency than elective abdominal surgery. The risk of post operative sepsis is related to the degree of contamination of the peritoneal cavity and the operation site. Antibiotics have only a secondary role in abdominal or wound sepsis and not a substitute for the eradication of the source of sepsis and thorough peritoneal or wound irrigation. Good surgical technique will avoid gross spillage from septic lesions or when the bowel is opened and prepared for anastomosis. Sepsis from inadequate attention to technique and incorrect surgical decision making (i.e. surgeon-related factor) remain the single most important factor that can influence the morbidity and mortality in abdominal surgery.

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