Using preoperative colon preparation to prevent surgical site infection

Elective colon and rectal resections have the highest rates of surgical site infection (SSI) of any elective procedure in contemporary surgery. One technique that can be used to prevent SSI is preoperative preparation of the colon. This article examines the efficacy of this procedure as well as providing tips for best practice. The author also outlines some future research topics.

INTRODUCTION

Elective colon and rectal resections have the highest rates of surgical site infection (SSI) of any elective procedure in contemporary surgery. SSI rates for elective colon resection were as high as 80-90% in the 1930s[1] although they improved to approximately 40% by the end of the 1960s.

Preoperative systemic antibiotics introduced by Polk and Lopez-Mayor[2] have further reduced SSI rates and performing further placebo-controlled trials to prove this point is considered unnecessary[3].

However, globally there is great variation in the reporting of SSI rates due to different criteria for what constitutes an infection and anomalies in post-discharge follow-up. During the last two decades, there have been three rigorously evaluated patient studies following elective colorectal resection[4-6]. The rate of SSI hovers around 20-25% in studies where systemic antibiotics were appropriately administered and where patients were monitored for 30 days postoperatively[4-6]. Clearly, more needs to be done to prevent the morbidity and cost of SSI following colon surgery.

The aim of mechanical bowel preparation is to remove faecal content from the large bowel, thereby reducing the rate of postoperative infections. Traditionally, this was performed using enemas in combination with oral laxatives but more recently oral cathartic agents that induce diarrhoea, such as polyethylene glycol and sodium phosphate, have been developed.

Preoperative preparation of the colon for the prevention of SSI has attracted a lot of attention. Human stool may contain as many as 10^{12} bacteria per gram and purging faecal matter before colonic surgery has always seemed intuitively correct[7]. However, mechanical cleansing alone does not reduce the density of bacteria in the mucosal fluid and it has never been shown to reduce SSI in isolation. This was recognised 70 years ago[8-10] and has been revalidated over the last 10 years by a host of clinical trials and the obligatory meta-analysis[11]. These recently identified failures of mechanical preparation

have led to some surgeons abandoning preoperative preparation altogether. Understanding the failure of mechanical preparation led investigators in the late 1930s to pursue possible antimicrobial methods of reducing bacterial concentration.

ORAL ANTIBIOTIC BOWEL PREPARATION

Despite early efforts with sulfa preparations[12] and kanamycin[13], a successful randomised clinical trial was not performed until Washington et al investigated the use of oral neomycin and tetracycline compared to mechanical preparation alone[14]. Clarke *et al*[15] validated the use of an neomycin and erythromycin base compared to mechanical preparation and a placebo.

This latter combination became popular in the US and by the end of the 1990s the oral antibiotic bowel preparation combined with preoperative systemic antibiotics was the most common strategy employed in elective colon surgery[16].

Lewis has further validated the merits of the oral antibiotic bowel preparation by conducting a randomised clinical trial of oral neomycin/metronidazole plus systemic antibiotics versus systemic antibiotics alone[17]. These findings were further validated by Lewis with a detailed meta-analysis of 13 total clinical trials demonstrating significance ($P < 0.0001$) in the combination of oral antibiotic bowel preparations allied with systemic antibiotics.

Despite the evidence supporting oral antibiotic bowel preparations, they are not widely used and have not been well received outside of the US and Canada.

Unfortunately, the quality of preoperative bowel preparation has often been suboptimal because of retained faecal material and reluctance by patients to complete the full requirements of the mechanical preparation. Patients have complained about the discomfort caused by the volume of fluid involved in mechanical preparation and the abdominal cramping associated with erythromycin has also resulted in poor compliance and a similar lack of adequate preparation for surgery.

Disillusionment among surgeons in all countries regarding this poor quality of preparation has led to abandonment of both oral and mechanical bowel preparations, and even some concern that the polyethylene glycol mechanical preparation may increase infection rates[18].

THE CORRECT TECHNIQUE

Over time the author has learned some effective clinical techniques for administering antibiotic bowel

preparation which can reduce SSI rates compared to those observed when systemic antibiotics are used in isolation. The following are important points:

- Patients and families must be well-informed about the details of the colorectal operation, the significance of complete colon preparation and the value of the correct use of the oral antibiotic regimen for the prevention of SSIs. Compliance with the preparation protocol is essential
- The mechanical preparation must be thorough and complete. The massive numbers of microbes in human stool mean that any retained stool will render oral antibiotics ineffective. It is likely that reduction in the density of microbes at the mucosal surface is the most important factor for preventing infection and retained stool interferes with this. A mechanical preparation of 48 hours or longer may be necessary in selected patients to achieve this goal of complete removal of all faecal matter[19]
- Allowing any colonic lavage fluid to be retained until the time of the operation is unacceptable. Any colonic lavage containing polyethylene glycol that is initiated within 12-16 hours of the operation will result in retained fluid and the potential for 'splash' during any resection. This subsequently increases the likelihood of SSI. Any colonic lavage must be completed by midday on the day before the operation
- Oral antibiotics should only be administered after the completion of mechanical bowel preparation. Administering neomycin capsules or tablets of any other antibiotic formulation while mechanical preparation is still in process can result in undissolved capsules and tablets being passed by the patient with no intraluminal antibiotic effect.

THE FUTURE

Even with the application of effective oral antibiotic bowel preparation and the appropriate use of systemic antibiotics, SSI rates may remain ≥5% and continued improvement in strategies to prevent SSIs in colon surgery need to be developed.

This continued SSI rate of ≥5% may be related to the fact that the development of oral antibiotic bowel preparations has been inconsistent over time and it remains unclear which regimen is best. Neomycin has been questioned in terms of its effectiveness[20] and is associated with gastrointestinal motility problems. Metronidazole is well-absorbed and because of this may not yield optimum intraluminal drug concentrations. Instead of additional trials challenging the use of mechanical preparation and re-affirming the literature of 70 years ago, new prospective trials evaluating different oral antibiotics are required.

There is some debate as to which form of mechanical bowel preparation is most efficacious as there have been many different preparations used. Polyethylene glycol is the most popular at present. One clinical trial identifies that sodium phosphate may provide the best result[21], although it has been associated with hyperphosphatemia[22].

One recent experimental investigation concludes that microbial virulence is enhanced when intracolonic phosphate concentrations are low and provides a scientific argument for including phosphate in the colonic preparation[23]. The different mechanical preparations need to be evaluated to define the best cleansing results, but also best patient acceptance.

Finally, it is widely accepted that combined oral antibiotic bowel preparation and concomitant systemic antibiotics disrupt the normal colonic ecosystem and one retrospective study implicates oral antibiotics in the postoperative development of Clostridium difficile enterocolitis[24]. It is certainly true that the inappropriate continuation of systemic antibiotics after completion of a colorectal resection will increase antibiotic-associated enterocolitis events. More research is needed into whether probiotics and prebiotics administered postoperatively help to restore the normal colonic microflora.

CONCLUSION

When it comes to the efficacy of oral antibiotic bowel preparation and the appropriate use of systemic antibiotics there are many unanswered questions. For example, is there a role for the intraoperative application of antibiotics or antiseptics to the surgical site? Can intraoperative pulsed-lavage reduce the microbial burden on the wound interface before closure? Could closed suction drains within a closed surgical incision reduce infection rates, especially in patients with a large body mass index (BMI)? What is the role of delayed primary closure or secondary closure in the wound where obvious contamination has occurred, or in the circumstance of emergent colonic resection where considerable contamination is encountered from pre-existent perforation? And are immediate negative pressure wound dressings appropriate in the open contaminated wound?

These and many other questions still continue to confront clinicians involved in colorectal surgery. In this author's opinion, considerable evidence supports the routine use of oral antibiotic bowel preparation in conjunction with effective mechanical preparation and this regimen deserves a broader application in practice.

AUTHOR DETAILS

Donald E Fry is Adjunct Professor of Surgery, Northwestern University, Feinberg School of Medicine, Chicago, Illinois and Emeritus Professor of Surgery, University of New Mexico School of Medicine, Albuquerque, New Mexico.

REFERENCES

1. Poth EJ. Historical development of intestinal antisepsis. *World J Surg* 1982; 6: 153-

9.
2. Polk HC Jr, Lopez-Mayor JF. Postoperative wound infection: a prospective study of determinant factors and prevention. *Surgery* 1969; 66: 97-103.
3. Baum ML, Anish DS, Chalmers TC, et al. A survey of clinical trials of antibiotic prophylaxis in colon surgery: evidence against further use of no-treatment controls. *N Engl J Med* 1981; 305: 795-9.
4. Milsom JW, Smith DL, Corman ML, et al. Double-blind comparison of single-dose alatrofloxacin and cefotetan as prophylaxis of infection following elective colorectal surgery. *Am J Surg* 1998; 176(Suppl 6A): 46S-52S.
5. Itani KMF, Wilson SE, Awad SS, et al. Ertapenem versus cefotetan prophylaxis in elective colorectal surgery. *N Engl J Med* 2006; 355: 2640-51.
6. Smith RL, Bohl JK, McElearney ST, et al. Wound infection after elective colorectal resection. *Ann Surg* 2004; 239: 599-607.
7. Ahmed S, Macfarlane GT, Fite A, et al. Mucosa-associated bacterial density in relation to human terminal ileum and colonic biopsy samples. *Appl Environ Microbiol* 2007; 73: 7435-42.
8. Garlock JH, Seley GP. The use of sulfanilamide in surgery of the colon and rectum. Preliminary report. *Surgery* 1939; 5: 787.
9. Firor WM, Jonas AF. The use of sulfanilylguanidine in surgical patients. *Ann Surg* 1941; 114: 19.
10. Firor WM, Poth EJ. Intestinal antisepsis with special reference to sulfanilylguanidine. *Ann Surg* 1941; 114: 663-71.
11. Zhu QD, Zhang QY, Zeng QQ, et al. Efficacy of mechanical bowel preparation with polyethylene glycol in prevention of postoperative complications in elective colorectal surgery: a meta analysis. *Int J Colorectal Dis* 2010; 25: 267-75.
12. Poth EJ, Ross CA. The clinical use of phthalylsulfathiazole. *J Lab Clin Med* 1944; 29: 785-808.
13. Cohn I Jr. Kanamycin for bowel sterilization. *Ann NY Acad Sci* 1958; 76: 212-7.
14. Washington JA II, Dearing WH, Judd ES, Elveback LR. Effect of preoperative antibiotic regimen on development of infection after intestinal surgery: prospective, randomized, double-blind study. *Ann Surg* 1974; 180: 567-71.
15. Clarke JS, Condon RE, Bartlett JG, et al. Preoperative oral antibiotics reduce septic complications of colon operations: results of prospective, randomized, double-blind clinical study. *Ann Surg* 1977; 186: 251-9.
16. Nichols RL, Smith JW, Garcia RY, et al. Current Practices of Preoperative Bowel Preparation Among North American Colorectal Surgeons. *Clin Infect Dis* 1997; 24: 609-19.
17. Lewis RT. Oral versus systemic antibiotic prophylaxis in elective colon surgery: a randomized study and meta-analysis send a message from the 1990s. *Can J Surg* 2002; 45:173-80.
18. Bucher P, Gervaz P, Soravia C, et al. Randomized clinical trial of mechanical bowel preparation versus no preparation before elective left-sided colorectal surgery. *Br J Surg* 2005; 92: 409-14.
19. Nichols RL, Briodo P, Condon RE, et al. Effect of preoperative neomycin-erythromycin intestinal preparation on the incidence of infectious complications following colon surgery. *Ann Surg* 1973;

178: 453-9.

20. Lewis RT, Goodall RG, Marien M, et al. Is neomycin necessary for bowel preparation in surgery of the colon? Oral neomycin plus erythromycin versus erythromycin-metronidazole. *Can J Surg* 1989; 32: 265-78.
21. Itani KMF, Wilson SE, Awad SS, et al. Polyethylene glycol versus sodium phosphate mechanical bowel preparation in elective colorectal surgery. *Am J Surg* 2007; 193: 190-94.
22. Ezri T, Lerner E, Muggia-Sullam M, et al. Phosphate salt bowel preparation regimens alter perioperative acid-base and electrolyte balance. *Can J Anesth* 2006; 53:153-8.
23. Long J, Zaborina O, Holbrook C, et al. Depletion of intestinal phosphate after operative injury activates the virulence of P aeruginosa causing lethal gut-derived sepsis. *Surgery* 2008; 144: 189-97.
24. Wren SM, Ahmed N, Jamal A, Safadi BY. Preoperative oral antibiotics in colorectal surgery increase the rate of Clostridium difficile colitis. *Arch Surg* 2005; 140: 752-56.