Chapter

Bowel Preparation before Elective Colorectal Surgery: Its Current Role

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Abstract

Bowel preparation for elective colorectal surgery has been performed for decades with the assumption to decrease infectious complications and anastomotic leaks. Nevertheless, the scientific basis of the same is still debatable. Various methods of bowel preparation are mechanical bowel preparation (MBP) with or without prophylactic oral antibiotics (POA), preoperative POA alone without MBP, and preoperative enema alone without MBP and POA. However, there is no consensus on the optimal type of bowel preparation. The available agents for MBP are polyethylene glycol (PEG) and sodium phosphate (NaP) or picosulphate. The most common prophylactic oral antibiotic regimen used in preoperative bowel preparation is Neomycin and Metronidazole a day before surgery, although the microbiological basis of this is unverified. Most studies around the beginning of this century indicate inadequate evidence for using MBP for colorectal surgery to suggest harm caused by the process and accordingly advise against it. However, several retrospective studies and meta-analyses, which were done after 2014, arguably demonstrate that preoperative MBP and POA reduce the postoperative surgical site infection rate. However, as per the current evidence, it can be suggested that MBP and preoperative POA can be safely included in the preoperative preparation of elective colorectal surgery.

Keywords: bowel preparation, colorectal surgery, mechanical bowel preparation, laparoscopic colorectal surgery, antibiotics, rectal surgery

1. Introduction

Bowel preparation refers to the mechanical cleansing of the bowel through the oral, rectal route, or a combined route. It has been in use for many decades as a part of preoperative preparation before elective colorectal surgery. However, the scientific basis of this practice is still debatable [1]. The infectious complication and anastomotic leak (2.7–20%) are the significant issues with colorectal surgery. These lead to increased morbidity in terms of postoperative ileus (10–30%), surgical site infection (6.5–20%), re-admission rate (8.1–11.8%), and an increase in the length of hospital stay (LOS) [1–7]. Colonic bacterial flora is one of the major causes of infectious complications in colorectal surgery, but the effective way to reduce the bacterial load is still debatable [8]. Preoperative bowel preparation is one of the techniques frequently studied to reduce these colonic bacterial florae. It is not easy to indicate when mechanical bowel preparation (MBP) was first used in colorectal surgery and is still the subject of debate.

Nevertheless, it is believed that preoperative mechanical bowel preparation (MBP) removes stool content and associated bacterial load, thereby reducing surgical site infection (SSI). The other benefit of MBP is easier bowel manipulation during surgery [9]. Subsequently, nonabsorbable antibiotics were added to reduce the bacterial load further. Since 1970, MBP plus poorly absorbed prophylactic oral antibiotics (POA) and intravenous antibiotics effective against intestinal microorganisms were accepted before elective colorectal surgery [10]. However, the effect of antibiotics is believed to last beyond the surgical intervention and can influence the structure and function of the gut microbiome [11]. The human intestine possesses millions of microbial genes, known as microbiome [12]. These microbiomes are highly specific, which is the reason for the conflicting data of MBP or the combination of MBP with POA [13]. Multiple clinical trials have been conducted to determine the best strategy for bowel preparation, but their results are controversial [14–16]. Since 1980, the evidence of Enhanced Recovery After Surgery (ERAS) and the successful outcome of emergency colorectal surgery has led to the belief that MBP can be omitted.

Many RCTs have failed to demonstrate any protective benefit of isolated MBP against infective complications or anastomotic leaks. On the contrary, the patients exhibited a paradoxical increase in postoperative ileus. Data from the late twentieth century studies suggest that the elimination of MBP does not increase morbidity. This gradually led to a trend of avoiding MBP routinely. Nevertheless, most of these studies have not combined the POA with MBP. Preoperative POA use has also decreased as surgeons started following ERAS. But the use of POA has not disappeared completely [17–20]. There is a resurgence of bowel preparation because of the high risk of surgical site infection after colorectal surgery. Since 2013, clinical guidelines have been changing, and a combination of MBP and POA is now recommended [21–23]. A number of retrospective studies and meta-analyses have been done after 2014, which have shown that preoperative MBP and POA following colorectal surgery reduce postoperative surgical site infection [24–28].

There are various methods of bowel preparation before elective colorectal surgery. These include MBP alone without a preoperative POA, MBP with preoperative POA, preoperative POA alone without MBP, and preoperative enema alone without MBP and POA. However, there is no consensus on the optimal type of bowel preparation, and it generally depends on the treating surgeon's preference and the patient's prognosis [29]. However, most surgeons prefer preoperative POA with MBP in elective colorectal surgery.

1.1 MBP alone

Before elective colorectal surgery, MBP was a standard method of care for over a century. The earliest mention in the literature about the practice of bowel decontamination was published in British Medical Journal in November 1899 by Burney Yeo in his article "a discussion of intestinal antiseptics" [30]. It has been performed since 1930 without any clear evidence of a reduction in complication [31]. There is a long history of research on preoperative MBP in colorectal surgery [32]. The most debated aspect of bowel preparation is its role in reducing surgical morbidity, such as surgical site infection (SSI) [29]. The SSI rate is highest in colorectal surgery, which varies between 5.4% and 23.2%, with a mean of 11.4% [33]. However, the evidence does not show any benefit of MBP in reducing the mucosa-associated bacterial load in the colon. Preoperative preparation before elective colorectal surgery was shifted to outpatient care, and the mortality rate continued to decrease. Surgeons started questioning the need for the MBP, and many centers appeared to confirm the abandonment of MBP [34]. One multicenter randomized control trial (RCT) published by Contant et al. with 1345 patients did not demonstrate any significant difference in anastomotic leak rates between patients who received MBP (n = 670) and those who did not (n = 684) [35]. In 2007, Jung et al. published another retrospective study of 1343 cases that reported similar results and suggested the omission of MBP before colorectal surgery [36]. Bucher et al. demonstrated significant adverse effects associated with MBP, such as loss of superficial mucus and infiltration of polymorphonuclear cells and lymphocytes suggesting inflammatory changes in the mucosa [37]. Several case reports demonstrated adverse side effects of MBP such as seizures and electrolyte imbalance such as hyponatremia, hypernatremia, hypocalcemia, and hyperphosphatemia [38–41]. The available agents for MBP are polyethylene glycol (PEG), sodium phosphate (NaP), and picosulphate. They have unpleasant side effects as well as the process is time-consuming. The preparation of sodium phosphate is palatable and made in 300 ml of water [42]. It principally acts as a purgative. Although it is better tolerated by the patients but is associated with fluid and electrolyte imbalance. It should not be given in patients with congestive cardiac failure, cirrhosis, or chronic kidney disease [43]. Full MBP in most RCT is done with an osmotic agent such as PEG with an electrolyte solution. The PEG–electrolyte solution is prepared in 2 liters (L) of water. The patient drinks 2 L of PEG–electrolyte solution and 1 L of clear fluid. PEG electrolyte solution minimizes fluid and electrolyte imbalance [44]. The outcome of agents such as sodium phosphate (NaP) or picosulphate in bowel preparation has not been studied as much as has been done with PEG. A clinical trial by Itani et al. in 2007 compared PEG with sodium phosphate and concluded that sodium phosphate is superior to PEG in bowel preparation [45]. Sodium phosphate (NaP) can be used as an enema or an oral preparation, but PEG is used as oral preparation only. The unclear benefit of MBP is a reduction in bacterial load within the bowel as it removes solid fecal content, makes easier manipulation of the bowel during surgery, and helps in performing intraoperative colonoscopy if needed. A number of RCTs [15, 16, 46–54], meta-analyses [55–63], and one Cochrane review [63] on MBP have been published but none of these have conclusively recommended any significant benefit of MBP alone in elective colorectal surgery. MBP has possible disadvantages, such as patient discomfort in the form of nausea, vomiting, abdominal distension, insomnia, and weakness. Other significant complications include fluid and electrolyte imbalance and alteration of gut microbiota and colonic mucus layer, which has been shown to cause increased bacterial translocation [37, 64]. However, the addition of nonabsorbable oral antibiotics with MBP decreases the SSI rates by approximately 40% when compared with that of MBP alone [25, 65, 66]. Many research studies have also evaluated bowel preparation with rectal enema alone without MBP and POA, and have observed a similar rate of wound infection and anastomotic dehiscence. However, bowel preparation with rectal enema alone without MBP and POA is not recommended (weak recommendation based on moderate-quality evidence, 2B) [67]. Preoperative MBP alone, without POA, is also not recommended for patients undergoing elective colorectal surgery (Grade of recommendation: strong recommendation based on high-quality evidence, 1A) [68].

1.2 MBP plus preoperative prophylactic oral antibiotics

Another aspect of bowel preparation is adding preoperative prophylactic oral antibiotics (POA) with MBP. Bowel preparation before colorectal surgery with POA was first proposed by Poth et al. in 1942 [69]. Whereas the combination of POA with MBP before elective colorectal surgery was introduced by Nichols et al. in 1971 [70]. In their landmark prospective randomized control trial comparing MBP with or without preoperative nonabsorbable oral antibiotics, Nichols et al. concluded a marked decrease in SSI with the use of a combination of MBP and POA [8, 70]. In their RCT, they used neomycin and erythromycin base and MBP. Interestingly, other studies have failed to demonstrate any significant protective benefit of this regimen against postoperative complications. Nichols et al., from their study, concluded that MBP did not decrease the microbial burden; rather, it facilitated the effect of oral antibiotics to decrease the mucosal concentration of bacteria [8, 70]. In 1980, most American and Canadian surgeons started using oral and parenteral antibiotic prophylaxis and MBP [71]. Later Smith MB et al., in 1990, highlighted the importance of oral antibiotics over intravenous antibiotics [72]. In 2002, Lewis conducted a prospective trial comparing parenteral antibiotics alone with a combination of parenteral and oral antibiotics. However, MBP was done in both these groups. He reported a lower incidence of SSI in the oral and parenteral antibiotic group [73]. In 2010, Markell et al., in their study, showed that only 39% of surgeons are using a POA, which was a substantial decrease in oral antibiotics use when compared to 1990 [74]. In the year 2015, combination of POA with MBP in elective colorectal surgery was reintroduced, but it became widespread in 2016 [75]. It is presumed that a combination of these two will give a synergistic effect. Nonabsorbable oral antibiotics, when combined with MBP, further reduce the intraluminal bacterial load and SSI rates [76]. However, the choice of antibiotics for this purpose is not clear. Different clinical trials have used different antibiotics, but these did not conclude which is better. Our knowledge has not moved beyond the existing formulation regimens for bowel preparation to advance our understanding of the pathogenesis of SSI and anastomotic leak. Overall perception indicates that antibiotics with both aerobic and anaerobic cover should be chosen [77]. Unfortunately, antibiotics used for bowel preparation have not changed in decades despite recognizing antibiotic resistance in surgical patients [78, 79]. Kirby et al., in their article, described the need for recalibration of antibiotics after reports from Leeds, United Kingdom, suggesting resistant Enterobacteriaceae responsible for SSI [80]. A randomized control trial by Clarke et al. demonstrated the role and efficacy of oral antibiotics in reducing SSI in elective colorectal surgery [81]. Many studies to date have demonstrated that oral nonabsorbable antibiotics before elective colorectal surgery prevent anastomotic leak more effectively than intravenous antibiotics alone [32]. The most common prophylactic oral antibiotic regimen used in these studies for preoperative bowel preparation is Neomycin (1 g) and Metronidazole (1 g) two times a day before surgery. However, the microbiological basis of this is unverified [82]. Only a few randomized clinical trials are in the literature on POA alone without MBP and POA with MBP. A recent meta-analysis conducted in 2018, which included two RCTs (n = 709) and two cohort studies (n = 22,774), did not find any difference in the overall incidence of SSI between the groups or even when RCTs and cohort studies were analyzed separately [83]. However, there is little level 1 evidence for POA alone without MBP [13], and therefore, preoperative POA without MBP is not recommended (Grade of recommendation: weak recommendation based on low-quality evidence, 2C) [29]. There is also no consensus on the optimal type of bowel preparation. Nichols et al. used the combination of oral Neomycin (1 g) and Erythromycin (1 g) dosages at 1:00 pm, 2:00 pm, and at 11:00 pm (total 6 g) a day before surgery along with MBP. They could reduce the fecal aerobic and anaerobic flora [84]. Neomycin and Erythromycin combination has been used for decades without any evidence of major side effects and many centers use a full MBP using PEG with electrolyte solution and two doses of oral Neomycin (1 g) and Metronidazole (1 g). Kim et al., in 2014, compared MBP with or without POA and found a significantly lower risk of surgical site infection (SSI) and Clostridium difficile colitis when both were used in combination. Michigan Surgical Quality Collaboration (MSQC) recommends full MBP and POA before colorectal surgery unless there is a contraindication for the same [85]. In 2015, Scarborough et al. compared the POA alone versus POA combined MBP, and their result supports the routine utilization of MBP with POA [17]. However, their POA alone group was comparatively smaller in size than the combined MBP and POA [17]. ERAS society also recommends the combination of preoperative MBP and POA before elective colorectal surgery [28]. Many centers use POA alone before elective colorectal surgery. Their results of using POA have been assessed in two large retrospective studies conducted by the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) on more than 30,000 patients and one large prospective meta-analyses on 69,000 patients. These have shown almost comparable or lower SSI rates among patients who received MBP plus POA versus those who received MBP alone [27, 83, 86]. Preoperative MBP and preoperative POA in elective colorectal surgery are recommended (strong moderate-quality evidence, 1B) [75, 87–90]. Currently, the practice can be summed up as: the MBP can be started two days before surgery and must be completed one day before surgery by 15:00 hours. The patient takes 1 g of Neomycin and 1 g of Metronidazole orally after completion of MBP at 15:00 and 23:00 hours. One hour before surgery, the patient should also receive perioperative intravenous antibiotics (Cefuroxime 1.5 g and Metronidazole 500 mg). The dose of intravenous antibiotics can be repeated if the duration of surgery is more than 3 hours [44].

1.3 MBP in elective rectal surgery

Data on MBP in patients with rectal surgery are not sufficient. Traditionally rectal washouts were done. The issues related to rectal surgery are different from those of colonic surgery. In low colorectal or coloanal anastomosis (anastomosis within 6 cm from the anal verge), a protective ostomy is often made because of the higher risk of anastomotic leak. A meta-analysis conducted on 28 RCTs and 12 cohort studies with 69,517 patients concluded that a combination of POA with MBP was associated with a significant reduction of SSI ($RR = 0.51$, $p < 0.00001$), anastomotic leak ($RR = 0.62$, $p < 0.00001$), 30 days mortality ($RR = 0.58$, $p < 0.0001$), overall morbidity ($RR = 0.67$, $p < 0.00001$), and postoperative ileus ($RR = 0.72$, $p = 0.04$) [83]. Anastomotic leak after rectal surgery is higher than that in colonic surgery [91]. Bretagnol et al. conducted a study on the role of MBP in rectal surgery, and they reported a higher infectious morbidity rate in the patient without MBP [92]. In contrast, Mahajna et al. reported that MBP causes liquid bowel contents, which lead to peritoneal spillage three times more frequently than when semisolid stool is present [93]. Results are not uniform regarding the use of oral antibiotics before rectal surgery, and very few studies have been done exclusively on rectal cancer patients [94]. Zmora et al. reported that some form of bowel preparation, such as rectal enema, is required before rectal surgery [14]. Bowel preparation with rectal enema is less invasive and well-tolerated and has not been associated with increased infectious morbidity [95]. However, more multicenter trials are required to gather evidence for MBP before rectal surgery.

1.4 MBP in laparoscopic surgery

There is a rise in laparoscopic resection for colon cancer. The laparoscopic technique has brought a significant decrease in SSI [96]. However, data on MBP in laparoscopic surgery are not sufficient. Many studies have not confirmed the effectiveness of preoperative MBP before laparoscopic surgery. However, proponents of MBP still recommend MBP before laparoscopic surgery for easier manipulation of the bowel and intracorporeal stapling, and reduction of fecal contamination in case of spillage during bowel resection [97–99]. In a retrospective review, Zmora et al. compared the outcomes of 68 laparoscopic colectomies with MBP and 132 without MBP. They did not find any benefit in the complication rates in the MBP group [100]. Chan et al. also reported a comparable 4.1% and 3.8% wound infection rate, an anastomotic leak at 1% and 0.6% in the no-MBP and MBP groups, respectively [101]. However, using MBP might improve the operative space due to improved view resulting from decreased colonic distension following MBP [102]. The RCT conducted by Won et al. reported a better surgical view in patients with MBP undergoing laparoscopic colorectal surgery [103]. However, this benefit may not be available in the presence of obstructing tumor that causes a decrease in operative space because of the distension of the proximal bowel [103]. Overall, MBP is widely preferred before laparoscopic colorectal surgery, but the best option is better left to the individual surgeon’s preference [104–106].

1.5 Using microbiome science to develop bowel preparation

Bowel preparation relies on the traditional paradigm [107, 108]. Still, there is a lack of recognition of the importance of normal microbiota in suppressing colonization resistance and promoting intestinal healing. The microbiota includes bacteria, viruses, fungi, and protozoans, which live symbiotically with humans. Gut microbiota (GM) are of two types. According to their location, they are named mucosal-associated microbiota (MAM) and luminal microbiota (LM). Bacteroidetes and Proteobacteria are representative of MAM, whereas Firmicutes and Actinobacteria are representative of the LM [109]. MAM stimulates the mucus secretion in the gut. It also produces short-chain fatty acids, acetate, butyrate, and propionate. These are the mediators of the host immune system. The LM, mainly Firmicutes, produces butyrate, which enhances intestinal barrier function and has anti-inflammatory and anticancer activity [110]. Studies lack how normal microbiota are reintroduced after surgery and provide health-promoting effects [111]. In the era of laparoscopic surgery, oral antibiotics may be less critical as the microbiota are minimally disturbed [94]. The intestinal decontamination, as complete as possible, should be the goal of adequate bowel preparation [112]. In current practice, by doing broad-based bowel preparation, decontamination of diverse GM happens. Diverse GM suppresses the development of potential harmful pathobionts and promotes intestinal healing. The next generation of bowel preparation using microbial metagenomics focuses on selective gut decontamination. Gentle bowel cleansing can begin with nutritional supplements and non-microbicidal anti-virulence agents. Here the nutritional supplement includes the nutrients known to suppress bacterial virulence without affecting their growth. Hence the normal GM proliferates but the virulence of pathogenic microbiota is suppressed [113]. Therefore, a balanced solution containing both nutrients and anti-virulence agents will be the next generation and more scientifically validated approach for bowel preparation before colorectal surgery that allows for targeted cleansing while preserving the vital function of the normal microbiota. However, evidence favored the MBP with POA before elective colorectal surgery. Now the time has come to allow the next-generation microbial science technology to recalibrate the traditional bowel preparation.

1.6 Bowel preparation and surgical recovery

The surgical recovery mainly focuses on the protective benefit of bowel preparation against SSI and anastomotic leak (AL), which in turn leads to increased intra-abdominal collections, reoperation rate, length of hospital stays (LOS), and 30 days' morbidity. Following colorectal surgery, about 20% of patients may suffer from SSI [114]. SSIs are associated with increased morbidity and LOS and delayed recovery. A number of high-quality studies report a reduction in SSI rates after MBP and POA [8, 70, 76, 115]. Klinger et al. analyzed subjects from the American College of Surgeons–National Surgical Quality Improvement Program (ACS-NSQIP) database and observed its protective benefit against SSI and AL rates [4, 17]. ACS-NSQIP data analysis also demonstrated a significant reduction in the readmission rate and LOS in a patient with MBP plus POA [28]. Interestingly, also it has been observed that AL following elective surgery for colorectal cancer adversely affects overall survival. It is probably because of increased local cancer recurrence as well as delays in starting the chemotherapy. Although the risk of AL is 2.2 times higher with only MBP, it decreases with the addition of POA [116], probably because the addition of POA reduces bowel bacterial colonization, which might lead to a decrease in infectious complications. Similar observations on recovery from laparoscopic colorectal surgery indicate that the LOS, complication rate, and reoperation rate decrease after the use of MBP and POA.

The protocol of enhanced recovery after surgery (ERAS) is established on the principle of reduction in surgically induced physiological and metabolic stress. The benefit of MBP plus POA can be a pillar in the ERAS pathway. ERAS society also recommends using preoperative MBP plus POA before elective colorectal surgery [28] because it reduces postoperative ileus [117], non-SSI-related complications [76], the LOS, and hospital readmission rates [118]. The ACS-NSQIP data indicate a reduction in 30-day mortality with MBP plus POA than not having bowel preparation at all, which is likely due to an overall decrease in septic complications [76]. These data suggest that bowel preparation (MBP plus POA) has a significant advantage on surgical recovery by reducing the SSIs, anastomotic leak, postoperative ileus, reoperation, and readmission rate as well as LOS and 30-day mortality.

2. Conclusion

MBP has no apparent benefit in reducing SSI when used alone. Current evidence suggests that SSI reduction occurs better when MBP is combined with POA. There is a possibility that the observed decrease in SSI might be due to the use of POA alone rather than the combination of MBP with POA. Emerging research on the microbiome will guide more specific bowel preparation regimens for the individual case. To date, the combination of preoperative MBP plus POA in elective colorectal surgery is recommended.

Funding

Nil.

Conflict of interest

The authors declare no conflict of interest.

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