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Original article

Surgeons' attitudes toward mechanical bowel preparation in the 21st century: A survey of the Caribbean College of Surgeons

Shamir O. Cawich*, Fawwaz Mohammed, Richard Spence, Patrick FaSiOen, Vijay Naraynsingh

Department of Clinical Surgical Sciences, University of the West Indies, St. Augustine, Trinidad and Tobago

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ABSTRACT

Background: The available evidence strongly supports the abolition of routine mechanical bowel preparation (MBP) for prophylaxis against infectious morbidity in elective colorectal surgery, except in very specific circumstances. Despite evidence-based recommendations, there is still great variation in clinical practice. We examined the clinical practices of general surgeons across the Caribbean.

Methods: We carried out a questionnaire study of all practicing surgeons at the annual symposium of the Caribbean College of Surgeons in June 2016. A standardized questionnaire was used as the data collection instrument. We attempted to classify the surgeons' responses into two groups: those who either used MBP inappropriately and/or cited an irrational reason for their choice and those who used MBP appropriately. Statistical analyses were performed using SPSS, version 16.0.

Results: There was a 53% (82/154) response rate: 46 (56.1%) surgeons used MBP selectively, 22 (26.8%) routinely used MBP, and 14 (17%) routinely omitted MBP. There were 19 (23.2%) surgeons who believed that MBP reduced infectious morbidity: 17 (20.7%) believed it reduced superficial surgical-site infections, 13 (15.9%) believed it reduced organ space infections, 13 (15.9%) believed it reduced anastomotic leaks, and 3 (3.7%) believed it reduced extraabdominal infections. Ten (12.2%) surgeons believed MBP was completely innocuous, and many respondents were unaware of potentially dangerous complications, including liver dysfunction (92.7%), cardiac events (67.1%), acute renal failure (65.9%), fluid shifts (28.1%), dehydration (28.1%), and electrolyte disturbances (18.3%). These findings were disappointing because they are pathophysiologic sequelae that have direct negative impact on patient recovery after colorectal surgery. Surgeons qualified for less than 5 years were likely to use MBP appropriately (87% vs 13%; $P < 0.001$), but those practicing in a service hospital (with no academic training programs) were more likely to use MBP inappropriately (35% vs 65%; P 0.02225).

Conclusions: It was disappointing that (1) 50% of surgeons used MBP inappropriately for irrational reasons or incorrect indications and (2) despite the knowledge of robust level I evidence not in support of MBP, a further 77% ignored the evidence and still routinely used MBP, citing “individual preference”. An educational campaign may be required to bring about practice change to align clinical practice with best practice recommendations.

1. Introduction

After elective colorectal resections, up to 26% of patients will develop infectious morbidity,[1] including superficial and deep surgical-site infections (SSIs), organ space infections, and anastomotic dehiscence. These complications lead to significant increases in hospitalization, postoperative recovery, and associated expenditure.[1,2]

There has been significant work on prophylaxis against these complications during elective colorectal resections, but there is still a wide variation of clinical practices across the globe, despite the existence of evidence-based recommendations.[1–9] Mechanical bowel preparation (MBP) was a common form of prophylaxis in the latter part of the 20th century. However, its role was questioned at the turn of the century after good-quality data challenged its value.[9–19]

* Corresponding author.
E-mail address: socawich@hotmail.com (S.O. Cawich).

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In this study, we sought to examine the clinical practices and knowledge of general surgeons across the Caribbean by performing a questionnaire survey of surgeons' practices.

2. Methods

We sought to document the knowledge and clinical practice of surgeons in the Caribbean, specifically in relation to MBP. Approximately 200 surgeons practice across the region, and most of them are fellows of the Caribbean College of Surgeons (CCOS). This professional society meets once a year at their annual clinical symposium. With the permission of the CCOS and ethical approval from the relevant institutional review board, we carried out a questionnaire study of all surgeons participating in the CCOS' annual symposium in June 2016.

Four independent investigators interviewed all participants, using a standardized questionnaire as the data collection instrument (appendix 1). Participants were included once they granted consent to participate and were in active practice in surgery. Medical students, nursing staff, and auxiliary healthcare workers who participated in the symposium were not interviewed for the study. All responses were codified, and statistical analyses were then performed using SPSS, version 16.0.

3. Results

The questionnaire was administered to 154 surgeons at the 2016 CCOS meeting. There were 82 respondents to the questionnaire study, representing a 53.3% response rate. The respondents volunteered the following responses:

3.1. Utilization of MBP

Of 82 respondents, 46 (56.1%) surgeons used MBP selectively before elective colorectal resections in their clinical practice, 22 (26.8%) surgeons routinely used MBP, and 14 (17%) routinely omitted MBP. A variety of MBP agents were utilized, including combinations of Fleet enemas (25), bowel irrigation with polyethylene glycol (18), liquid diets for 36–48 h before surgery (21), oral sodium phosphate preparations (34), oral nonabsorbable antibiotics (3), oral magnesium preparations (2), and/or bisacodyl (1).

3.2. Knowledge of evidence

There were 82 surgeons who stated that they were aware of the existing data on MBP. Sixty-three (76.8%) surgeons believed that the existing evidence was equivocal or did not demonstrate any significant reduction in the incidence of overall infectious morbidity.

Nineteen (23.2%) surgeons believed that MBP contributed to an overall reduction in infectious morbidity. Of this, 17 (20.7%) believed that there was strong evidence that MBP reduced the incidence of superficial SSI, 13 (15.9%) believed it reduced organ space infections, 13 (15.9%) believed it reduced anastomotic leaks, and 3 (3.7%) believed it reduced extraabdominal infections.

In those 13 respondents who believe MBP reduced anastomotic leaks, 11 thought this statement applied to rectal operations alone and 2 believed it applied to all gastrointestinal anastomoses. Sixty-nine (84.2%) surgeons thought that MBP had no effect on anastomotic leaks.

3.3. Surgeons' attitudes

For the 22 surgeons who routinely used MBP, the most common rationale cited by 17 (77%) respondents was “surgeon preference”. Other reasons were support from existing data (3), dictated by hospital policy (1), and to facilitate intraoperative colonoscopy (1).

The 14 surgeons who routinely omitted MBP stated that the reason for their choice was evidence-based recommendations (10) and “surgeon preference” (4).

When the 46 surgeons who practiced selective MBP were surveyed, 22 (47.8%) did so to facilitate laparoscopic resections, 14 (30.4%) cited surgeon preference only, 5 (10.9%) for rectal operations, and 5 (10.9%) to facilitate intraoperative colonoscopy.

3.4. Awareness of MBP complications

We asked 82 surgeons if they were aware of any negative sequalae of MBP use. Ten (12.2%) surgeons were unaware of any complications whatsoever from MBP use. The remaining 72 (87.8%) surgeons were aware of at least one potential complication. Sixty-seven surgeons were aware of electrolyte disturbances as a potential complication. Other known potential complications included dehydration (59), fluid shifts (59), cardiac sequalae (27), renal failure (28), liver dysfunction (6), and neurologic sequelae (6).

4. Discussion

In the early 20th century, colorectal surgery was accompanied by a high rate of infectious morbidity. It appeared logical that evacuation of feces, with its high microbial content, could reduce infectious morbidity. Several methods were used to achieve this, including dietary manipulation, oral charcoal, laxatives, cathartics, bowel irrigation, and enemas. This thinking became so popular that by the mid-20th century, surgeons routinely used MBP to evacuate feces before elective colorectal operations.

The use of MBP was justified in several ways: Intraoperatively, it was easier to handle an empty colon,[20] a technically better anastomosis could be created with no luminal content present,[20] there would be less spillage of feces during bowel transection,[21] and there would be less microbes in the field with the opportunity to create infections.[21,22] In the postoperative period, it was postulated that there would be no hard stool to put mechanical stress on the fresh anastomosis[23] and the change in luminal pH would reduce ammonia production, preventing its cytotoxic effect on anastomoses.[24,25]

The evidence supporting these theories was weak, predominantly coming from small animal studies showing greater anastomotic bursting pressures and ex vivo leaks.[24–26] The most robust evidence came from O'Dwyer et al.[26] who randomized 36 dogs to anterior resections with or without MBP. They were able to show a reduction in anastomotic leaks (13% vs 47%) and organ space infections (6% vs 29%) in the dogs that had MBP.[26] Despite the weak evidence to support it, MBP became accepted as standard care in that era.

Further work elucidated some reasons that a reduction in fecal load may not be beneficial. To understand this, we must appreciate the difference between intraluminal versus mucosa-associated bacteria. Mucosa-associated bacteria are either adherent to or trapped in mucus at the colonic epithelium. These mucosa-associated bacteria can contribute to SSI. However, they are not significantly affected by MBP[27] that only evacuates intraluminal feces and luminal bacteria. When Smith et al.[28] examined tissue cultures in animals that had intraoperative colonic lavage, they demonstrated >10,000-fold reductions in intraluminal bacteria but insignificant changes in mucosa-associated bacteria.[27,28] This can explain the lack of influence of MBP on SSIs.

When the evidence is examined closely, it is clear that the evidence in support of MBP was of poor quality. In light of this, it was

disappointing that 20.7% of surgeons thought there was strong evidence to support MBP. We were also surprised that many surgeons believed that MBP reduced the incidence of superficial SSI (20.7%), organ space infections (15.9%), anastomotic leaks (15.9%), and incidence of extraabdominal infections (3.7%).

In the latter part of the 20th century, surgeons began to appreciate the undesirable side effects such as fluid shifts, electrolyte disturbances, nausea, vomiting, abdominal pain, and poor patient tolerability.[29–31] It was interesting that 12.2% of respondents thought that MBP was completely innocuous, with no potential complications at all. But, it was alarming that the respondents were unaware of the following potential complications: liver dysfunction (92.7%), cardiac events (67.1%), acute renal failure (65.9%), fluid shifts (28.1%), dehydration (28.1%), and electrolyte disturbances (18.3%). These responses were disappointing because these are pathophysiologic sequelae that have direct negative impact on patient recovery after colorectal surgery. As with any other intervention, it should be reasonable to expect that end users are aware of benefits and potential risks of their interventions.

The pendulum really swung when trauma surgeons reported good outcomes after emergency operations in unprepared bowel for patients with penetrating colonic injuries, even in the presence of fecal contamination and delays to repair.[32–34] These reports stimulated researchers to investigate the value of MBP in elective colorectal operations with well-designed studies.

The first reports were both published in 1994 by Santos et al.[35] and Burke et al.[36] Burke et al.[36] randomized 186 patients to elective colorectal operations with or without MBP. After not being able to demonstrate any difference in anastomotic leaks between patients with or without MBP (8% vs 11%; $P > 0.9$), Burke et al.[36] suggested that MBP was unnecessary because it did not influence outcomes in colorectal surgery. In the same year, Santos et al.[35] randomized 149 patients undergoing elective colorectal surgery to receive intravenous antibiotics (metronidazole plus cephalothin), with or without preoperative MBP. They reported that MBP led to significantly more wound infections (24% vs 12%, $P < 0.05$) and a worrisome trend toward increased anastomotic leaks (10% vs 5%). Santos et al.[35] were the first to suggest that MBP was not only unnecessary but also harmful to patients undergoing elective colorectal surgery.

Over the next decade, two additional well-designed studies were published which also suggested that MBP was harmful.[29,37] Bucher et al.[29] randomized MBP in 153 patients undergoing elective colorectal surgery. They reported that MBP significantly increased wound infections (13% vs 4%; $P = 0.07$; relative risk [RR], 1.58; confidence interval [CI], 0.97–2.34), overall complications (22% vs 8%; $P = 0.028$; RR, 1.58; CI, 1.16–2.14), extraabdominal complications (24% vs 11%; $P = 0.034$; RR, 1.5; CI, 1.11–2.04), and the duration of hospitalization (11.7 ± 5.2 vs 9.1 ± 2.7 days; $P = 0.001$), even in those patients who did not experience complications. In a later publication, Bucher et al.[37] microscopically examined healthy colon at the proximal resection margins in 50 patients having elective operations with and without MBP. They described potentially dangerous microscopic changes that were significantly more common in patients who had MBP: loss of superficial mucus (96% vs 52%; $P < 0.001$), loss of epithelial cells (88% vs 40%; $P < 0.01$), mucosal inflammation (48% vs 12%; $P < 0.02$), and polymorphonuclear cell infiltration (52% vs 8%; $P < 0.02$).[37]

By the early 21st century, nine well-designed prospective randomized trials evaluating the value of MBP were published.[29,35–42] The reports all suggested that MBP did not influence the outcomes of colorectal surgery[29,35–42] but were inconsistent in demonstrating harm.[29,35,37] Therefore, several large meta-analyses were commissioned to evaluate the existing data.[10–19,43]

Although the earlier meta-analyses suggested that MBP was harmful by significantly increasing the rate of anastomotic leaks,[11–13] SSIs,[43] and postoperative cardiac events,[10] the more recent meta-analyses did not corroborate this. The more recent reviews that included larger numbers in the study population could not demonstrate harm.[15–19] But, all the meta-analyses are in agreement that there is no benefit of MBP in elective colorectal surgery.[10–13,15–19,43]

We already discussed our disappointment that 18% of surgeons who routinely used MBP thought that there was good evidence in support of MBP. We also uncovered that a high percentage of surgeons were completely unaware of the potential complications associated with MBP. But, it was more disappointing to learn that despite the existence of robust level I evidence data proving that there is no benefit to MBP, a further 77% ignored the existing data and still routinely used MBP, citing their individual "preference." This is not in keeping with the modern principles of evidence-based medicine. Only 17% of those surveyed routinely avoided MBP and were familiar with the relevant evidence to do so.

Although there is sufficient evidence to make grade A recommendations to avoid routine MBP in modern colorectal surgery, there are specific circumstances in which MBP may be justified: patients with tumors <2 cm diameter that may not be easily appreciated intraoperatively, those who require intraoperative colonoscopy, those who are scheduled for laparoscopic colectomy, and those in whom a restorative proctectomy is scheduled.[29] There were 44 surgeons in our survey who used MBP selectively, and 66% of them cited appropriate reasons for this practice, including intended laparoscopic resections (22), rectal operations (5), and intraoperative colonoscopies (4). The remaining 15 (34%) of surgeons did not seem to have rational explanations, again citing "surgeon preference" as the reason for their practice.

Based on their response, we attempted to classify the surgeons' responses into two groups: those who either used MBP inappropriately and/or cited an irrational reason for their choice, and we compared this group to those to used MBP appropriately and cited a reasonable rationale for their choice. Of 82 respondents, 41 (50%) respondents used MBP appropriately. The remaining 50% either cited an irrational reason or incorrect indication for MBP use. In Table 1, we compared the demographics of those who used MBP appropriately and those who did not (Table 1). We could not find any statistical difference in appropriate use of MBP when we examined surgeons by practice type or case volumes. However, surgeons who were qualified for less than five years (87% vs 13%; $P < 0.05$) were significantly more likely to use MBP appropriately. Surgeons who practiced at a service hospital (with no academic training programs) were

Table 1
Analysis of respondents' qualifications and practice type.

Parameter	Appropriate (41)	Inappropriate use (41)	P value
Qualified surgeon			
Qualified <5 years	13/15 (87%)	2/15 (13%)	**0.00006**
Qualified 5–10 years	12/19 (63%)	7/19 (37%)	0.1048
Qualified >5 years	11/29 (38%)	18/29 (62%)	0.6602
Type of practice			
Private practice only	6/10 (60%)	4/10 (40%)	0.3711
Service type hospital	11/31 (35%)	20/31 (65%)	**0.02225**
Academic hospital	24/41 (59%)	17/41 (41%)	0.1221
Volume of colorectal cases per year			
<10 per year	12/23 (52%)	11/23 (48%)	0.7681
11–20 per year	20/36 (56%)	16/36 (44%)	0.3458
>20 per year	9/23 (39%)	14/23 (61%)	0.1404

The bold text simply identifies the parameters that achieved statistical significance, with a P Value <0.05.

significantly more likely to use MBP inappropriately (35% vs 65%; P 0.02225).

5. Conclusion

The available evidence strongly supports the abolition of routine MBP for SSI prophylaxis in elective colorectal surgery, except in very specific circumstances. Despite the existence of evidence-based recommendations governing the use of MBP in elective colorectal surgery, there is still great variation in clinical practice.

In this group, 18% believed that there was good scientific evidence to support MBP, 12.2% believed MBP was completely innocuous, and a high proportion of respondents were unaware of potentially dangerous complications: liver dysfunction (92.7%), cardiac events (67.1%), acute renal failure (65.9%), fluid shifts (28.1%), dehydration (28.1%), or electrolyte disturbances (18.3%). These findings were disappointing because they are pathophysiologic sequelae that have direct negative impact on patient recovery after colorectal surgery. Therefore, interventions are required to increase the current level of knowledge.

When we examined existing practices, there was no difference in appropriate use of MBP when we examined surgeons by practice type or case volumes. However, surgeons who were qualified for less than five years were significantly more likely to use MBP appropriately. Surgeons who practiced at a service hospital (with no academic training programs) were significantly more likely to use MBP inappropriately (35% vs 65%; P 0.02225).

It was disappointing that (1) 50% of surgeons used MBP inappropriately for irrational reasons or incorrect indications and (2) despite the knowledge of robust level I evidence not in support of MBP, a further 77% ignored the evidence and still routinely used MBP, citing “individual preference”. An educational campaign may be required to bring about practice change to align clinical practice with best practice recommendations.

Author contributions

S.O.C designed the study. All the authors performed the research, analyzed the data, wrote the article, and revised the manuscript for final submission.

Institutional review board statement

This research was approved by the local institutional review board, at the University of the West Indies' Ethics Committee.

Conflict of interest statement

The authors declare that there are no financial relationships, personal relationships, or other scenarios that may represent potential conflicts of interest.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.cmrp.2019.02.001.

References

1. Bellows CF, Mills KT, Kelly TN, Gagliardi G. Combination of oral non-absorbable and intravenous antibiotics versus intravenous antibiotics alone in the prevention of surgical site infections after colorectal surgery: a meta-analysis of randomized controlled trials. *TechColoproctol*. 2011;15:385–395. https://doi.org/10.1007/s10151-011-0714-4. PMID: 21785981.
2. Eagye KJ, Nicolau DP. Deep and organ-space infections in patients undergoing elective colorectal surgery: incidence and impact on hospital length of stay and costs. *Am J Surg*. 2009;198:359–367. https://doi.org/10.1016/j.amjsurg.2008.11.030. PMID: 19306972.
3. Bartlett JG, Condon RE, Gorbach SL, Clarke JS, Nichols RL, Ochi S. Veterans administration cooperative study on bowel preparation for elective colorectal operations: impact of oral antibiotic regimen on colonic flora, wound irrigation cultures and bacteriology of septic complications. *Ann Surg*. 1978;188:249–254 [PMID: 686893; DOI: not listed].
4. Song F, Glenny AM. Antimicrobial prophylaxis in colorectal surgery: a systematic review of randomized controlled trials. *Br J Surg*. 1998;85(9):1232–1241. https://doi.org/10.1046/j.1365-2168.1998.00883.x. PMID: 9752867.
5. 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;45:173–180 [PMID: 12067168; DOI: Not listed].
6. Bratzler DW, Hunt DR. The surgical infection prevention and surgical care improvement projects: national initiatives to improve outcomes for patients having surgery. *Clin Infect Dis*. 2006;43:322–330. https://doi.org/10.1086/505220. PMID: 16804848.
7. Horan TC, Andrus M, Dudeck MA. CDC surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Contr*. 2008;36:309–332. https://doi.org/10.1016/j.ajic.2008.03.002. PMID: 18538699.
8. Nelson RL, Gladman E, Barbateskovic M. Antimicrobial prophylaxis for colorectal surgery. *Cochrane Database Syst Rev*. 2014;5:CD001181. https://doi.org/10.1002/14651858.CD001181.pub4. PMID: 24817514.
9. Guenaga KK, Matos D, Wille-Jorgenses P. Mechanical bowel preparation for elective colorectal surgery. *Cochrane Database Syst Rev*. 2009;21(1):CD001544. https://doi.org/10.1002/14651858.CD001544.pub3. PMID: 19160198.
10. Gravante G, Caruso R, Andreani SM, Giordano P. Mechanical bowel preparation for colorectal surgery: a meta-analysis on abdominal and systemic complications on almost 5000 patients. *Int J Colorectal Dis*. 2008;23(12):1145–1150. https://doi.org/10.1007/s00384-008-0592-z. PMID: 18836729.
11. Slim K, Vicaut E, Panis Y, Chipponi J. Meta-analysis of randomized clinical trials of colorectal surgery with or without mechanical bowel preparation. *Br J Surg*. 2004;91(9):1125–1130. https://doi.org/10.1002/bjs.4651. PMID: 15449262.
12. Bucher P, Mermillod B, Morel P, Soravia C. Does mechanical bowel preparation have a role in preventing postoperative complications in elective colorectal surgery? *Swiss Med Wkly*. 2004;134(5):69–74 [PMID: 15113054; DOI Not listed].
13. Wille-Jørgensen P, Guenaga KF, Matos D, Castro AA. Pre-operative mechanical bowel cleansing or not? An updated meta-analysis. *Colorectal Dis*. 2005;7(4):304–310. https://doi.org/10.1097/01.DCR.0000080151.35300.20. PMID: 12907890.
14. Pineda CE, Shelton AA, Hernandez-Boussard T, Morton JM, Welton ML. Mechanical bowel preparation in intestinal surgery: a meta-analysis and review of the literature. *J Gastrointest Surg*. 2008;12(11):2037–2044. https://doi.org/10.1007/s11605-008-0594-8. PMID: 18622653.
15. Slim K, Vicaut E, Launay-Savary MV, Contant C, Chipponi J. Updated systematic review and meta-analysis of randomized clinical trials on the role of mechanical bowel preparation before colorectal surgery. *Ann Surg*. 2009;249(2):203–209. https://doi.org/10.1097/SLA.0b013e318193425a. PMID: 19212171.
16. Zhu QD, Zhang QY, Zeng QQ, Yu ZP, Tao CL, Tang WJ. 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(2):267–275. https://doi.org/10.1007/s00384-009-0834-8. PMID: 19924422.
17. Eskicioglu C, Forbes SS, Fenech DS, McLeod RS. Best Practice in General Surgery Committee Preoperative bowel preparation for patients undergoing elective colorectal surgery: a clinical practice guideline endorsed by the Canadian Society of Colon and Rectal Surgeons. *Can J Surg*. 2010;53(6):385–395 [PMID: 21092431; DOI Not listed].
18. Güenaga KF, Matos D, Wille-Jørgensen P. Mechanical bowel preparation for elective colorectal surgery. *Cochrane Database Syst Rev*. 2011;9:CD001544. https://doi.org/10.1002/14651858.CD001544.pub4. PMID: 21901677.
19. Cao F, Li J, Li F. Mechanical bowel preparation for elective colorectal surgery: updated systematic review and meta-analysis. *Int J Colorectal Dis*. 2012;27(6):803–810. https://doi.org/10.1007/s00384-011-1361-y. PMID: 22108902.
20. van Geldere D, Fa-Si-Oen P, Noach LA, Rietra PJ, Peterse JL, Boom RP. Complications after colorectal surgery without mechanical bowel preparation. *J Am Coll Surg*. 2002;194(1):40–47. https://doi.org/10.1016/S1072-7515(01)01131-0. PMID: 11803995.
21. Fa-Si-Oen PR, Verwaest C, Buitenweg J, et al. Effect of mechanical bowel preparation with polyethyleneglycol on bacterial contamination and wound

infection in patients undergoing elective open colon surgery. *Clin Microbiol Infect*. 2005;11(2):158–160. https://doi.org/10.1111/j.1469-0691.2004.01012.x. PMID: 15679494.
22. Fa-Si-Oen PR, Kroeze F, Verhoef LH, Verwaest C, Roumen RM. Bacteriology of abdominal wounds in elective open colon surgery: a prospective study of 100 surgical wounds. *Clin Microbiol Infect*. 2005;11(2):155–157. https://doi.org/10.1111/j.1469-0691.2004.01011.x. PMID: 15679473.
23. Fa-Si-Oen P, Roumen R, Buitenweg J, et al. Mechanical bowel preparation or not? Outcome of a multicenter randomized trial in elective open colon surgery. *Dis Colon Rectum*. 2005;48(8):1509–1516. https://doi.org/10.1007/s10350-005-0068-y. PMID: 15981065.
24. Irvin TT, Bostock T. The effects of mechanical preparation and acidification of the colon on the healing of colonic anastomoses. *Surg Gynecol Obstet*. 1976;143(3):443–447 [PMID: 8849; DOI: Not listed].
25. Charoenkul V, McElhinney JA, Hodgson JB. Acidification of rat colon with lactulose: its effects on the healing of colonic anastomoses. *Arch Surg*. 1978;113:618–620. https://doi.org/10.1001/archsurg.1978.01370170080016. PMID: 25642.
26. O'Dwyer PJ, Conway W, McDermott EW, O'Higgins NJ. Effect of mechanical bowel preparation on anastomotic integrity following low anterior resection in dogs. *Br J Surg*. 1989;76(7):756–758. https://doi.org/10.1002/bjs.1800760738. PMID: 2765820.
27. Lindsey JT, Smith JW, Mc Clugage Jr SG, Nicholas RL. Effects of commonly used bowel preparations on the large bowel mucosal-associated and luminal microflora in the rat model. *Dis Colon Rectum*. 1990;33(7):554–560. https://doi.org/10.1007/BF02052206. PMID: 2361422.
28. Smith MB, Baliga B, Santor WM, GoradiaVK, Holmes JW, Nichols RL. Intraoperative colonic lavage: failure to decrease mucosal microflora. *South Med J*. 1991;84(1):38–42. https://doi.org/10.1097/00007611-199101000-00010. PMID: 1986426.
29. Bucher P, Gervaz P, Soravia C, Mermillod B, Erne M, Morel P. Randomized clinical trial of mechanical bowel preparation versus no preparation before elective left-sided colorectal surgery. *Br J Surg*. 2005;92(4):409–414. https://doi.org/10.1002/bjs.4900. PMID: 15786427.
30. Oliviera L, Wexner SD, Daniel N, et al. Mechanical bowel preparation for elective colorectal surgery. A prospective, randomized, surgeon-blinded trial comparing sodium phosphate and polyethylene glycol-based oral lavage solutions. *Dis Colon Rectum*. 1997;40:585–591. https://doi.org/10.1016/S0022-5347(01)62180-3. PMID: 9152189.
31. Yoshioka K, Connolly AB, Ogunbiyi OA, Hasegawa H, Morton DG, Keighley MR. Randomized trial of oral sodium phosphate compared with oral sodium picosulphate (picolax) for elective colorectal surgery and colonoscopy. *Dig Surg*. 2000;17:66–70. https://doi.org/10.1159/000018802. PMID: 10720834.
32. Sasaki LS, Allaben RD, Golwala R, Mittal VK. Primary repair of colon injuries: a prospective Randomized study. *J Trauma*. 1995;39:895–901. https://doi.org/10.1097/00005373-199511000-00013. PMID: 7477005.
33. Gonzalez RP, Merlotti GJ, Holevar MR. Colostomy in penetrating colon injury. Is it necessary? *J Trauma*. 1996;41:271–275. https://doi.org/10.1097/00005373-199608000-00012. PMID: 8760535.
34. Curran TJ, Bortozza AP. Complications of primary repair of colon injury: literature review of 2964 cases. *Am J Surg*. 1999;177:42–47. https://doi.org/10.1016/S0002-9610(98)00293-1. PMID: 10037307.
35. Santos JC, Batista J, Sirimarco MT, Guimaraes AS, Levy CE. Prospective randomized trial of mechanical bowel preparation in patients undergoing elective colorectal surgery. *Br J Surg*. 1994;81(11):1673–1676. https://doi.org/10.1002/bjs.1800811139. PMID: 7827905.
36. Burke P, Mealy K, Gillen P, Joyce W, Traynor O, Hyland J. Requirement for bowel preparation in colorectal surgery. *Br J Surg*. 1994;81(6):907–910. https://doi.org/10.1002/bjs.1800810639. PMID: 8044619.
37. Bucher P, Gervaz P, Egger JF, Soravia C, Morel P. Morphologic alterations associated with mechanical bowel preparation before elective colorectal surgery: a randomized trial. *Dis Colon Rectum*. 2006;49(1):109–112. https://doi.org/10.1007/s10350-005-0215-5. PMID: 16273330.
38. Alcantara Moral M, Serra Aracil X, Bombardó Juncá J, et al. A prospective, randomised, controlled study on the need to mechanically prepare the colon in scheduled colorectal surgery. *Cir Esp*. 2009;85(1):20–25. https://doi.org/10.1016/S2173-5077(09)70112-7. PMID: 19239933.
39. Zmora O, Mahajna A, Bar-Zakai B, et al. Is mechanical bowel preparation mandatory for left-sided colonic anastomosis? Results of a prospective randomized trial. *Tech Coloproctol*. 2006;10(2):131–135. https://doi.org/10.1007/s10151-006-0266-1. PMID: 16773286.
40. Ram E, Sherman Y, Weil R, Vishne T, Kravarusic D, Dreznik Z. Is mechanical bowel preparation mandatory for elective colon surgery? A prospective randomized study. *Arch Surg*. 2005;140(3):285–288. https://doi.org/10.1001/archsurg.140.3.285. PMID: 15781794.
41. Zmora O, Mahajna A, Bar-Zakai B, et al. Colon and rectal surgery without mechanical bowel preparation: a randomized prospective trial. *Ann Surg*. 2003;237(3):363–367. https://doi.org/10.1097/01.SLA.0000055222.90581.59. PMID: 12616120.
42. Miettinen RP, Laitinen ST, Mäkelä JT, Pääkkönen ME. Bowel preparation with oral polyethylene glycol electrolyte solution vs no preparation in elective open colorectal surgery: prospective randomized study. *Dis Colon Rectum*. 2000;43(5):669–677. https://doi.org/10.1007/BF02235585. PMID: 10826429.
43. Platell C, Hall J. What is the role of mechanical bowel preparation in patients undergoing colorectal surgery? *Dis Colon Rectum*. 1998;41(7):875–883. https://doi.org/10.1007/BF02235369. PMID: 9678373.