To cite this article: Kartal B, Bozkurt AM, Seyhun C. Comparıson of preoperatıve bowel preparatıon models of patıents who underwent surgery for colorectal cancer Turk J Clin Lab 2023; 1: 154-160.

Original Article

Comparıson of preoperatıve bowel preparatıon models of patıents who underwent surgery for colorectal cancer

Kolorektal kanser nedeniyle ameliyat giren hastaların ameliyat öncesi bağırsak hazırlık modellerinin karşılaştırılması

Bahadir Kartal*[1], Mehmet Abdussamet Bozkurt[2] , Cemal Seyhun[3]

[1]Hitit University, Erol Olcok Training and Research Hospital, Department of General Surgery, Corum, Turkey
[2]Istinye University, Department of General Surgery, Istanbul, Turkey
[3]Dr. Burhan Nalbantoglu State Hospital, Department of General Surgery, Nicosia, Cyprus

Abstract

Aim: The most prevalent cancer in society is colorectal cancer (CRC). Studies aiming to lower surgical morbidity and mortality have found a significant contribution from preoperative bowel preparation. Models for bowel preparation included mechanical cleaning, the use of antibiotics, and control groups. We compared preoperative bowel preparation for elective colorectal cancer and evaluated its effects in this study.

Material and Methods: Preoperative bowel preparation model was used to prospectively split 144 patients (n=144) with colorectal cancer into four groups. Patients in the first group (Group I) underwent mechanical bowel preparation (MBP), followed by oral antibiotic therapy (OAB) and MBP in the second group (Group II), intravenous antibiotic therapy (IVAB), MBP, and OAB in the third group (Group III), and no bowel preparation in the fourth group (Group IV). Demographic information, anastomotic leakage, surgical site infection, intraabdominal abscess, postoperative ileus, and death were compared between patients.

Results: Groups I, II, III, and IV of the study each had 35 patients, 38 patients, 35 patients, and 36 patients, respectively. There was no statistically significant difference between the four groups when the groups were evaluated by age, gender, and ASA (American Society of Anesthesiologists) score ($p > 0.05$). There were significant differences between surgical site infection (SSI), intraabdominal abscess, and anastomosis leaking (p0.05). Mortality and postoperative ileus did not differ significantly ($p > 0.05$).

Conclusion: We consider that the bowel preparation approach of mechanical colon cleansing and antibiotic administration is appropriate for patients who have had surgery owing to elective CRC.

Keywords: Colorectal cancer, bowel preparation, surgery

Corresponding Author*: Bahadır Kartal, Hitit University, Erol Olcok Training and Research Hospital, Department of General Surgery, Corum, Turkey
E-mail: dr.bkartal@hotmail.com
Orcid: 0000-0003-1647-9979
Doi: 10.18663/tjcl.1234192
Recevied: 14.01.2023 Accepted: 02.02.2023

TJCL Volume 14 Number 1 p: 154-160

Öz

Amaç: Toplumda en sık görülen kanser kolorektal kanserdir (KRK). Cerrahi morbidite ve mortaliteyi azaltmayı amaçlayan çalışmalar, preoperatif barsak hazırlığının önemli bir katkısını bulmuştur. Bağırsak hazırlığı için modeller arasında mekanik temizlik, antibiyotik kullanımı ve kontrol grupları yer alıyordu. Bu çalışmada elektif kolorektal kanser için preoperatif barsak hazırlığını karşılaştırdık ve etkilerini değerlendirdik.

Gereç ve Yöntemler: Kolorektal kanserli 144 hastayı (n=144) prospektif olarak dört gruba ayırmak için preoperatif barsak hazırlama modeli kullanıldı. Birinci gruptaki hastalara (Grup I) mekanik barsak hazırlığı (MBH), ikinci gruba (Grup II) oral antibiyotik tedavisi (OAB) ve MBH, üçüncü gruba intravenöz antibiyotik tedavisi (IVAB), MBH ve OAB uygulandı. grup (Grup III) ve dördüncü grupta (Grup IV) barsak hazırlığı yapılmadı. Hastalar arasında demografik bilgiler, anastomoz kaçağı, cerrahi alan enfeksiyonu, karın içi apse, postoperatif ileus ve ölüm karşılaştırıldı.

Bulgular: Çalışmanın Grup I, II, III ve IV'ünde sırasıyla 35 hasta, 38 hasta, 35 hasta ve 36 hasta vardı. Gruplar yaş, cinsiyet ve ASA (American Society of Anesthesiologists) puanına göre değerlendirildiğinde dört grup arasında istatistiksel olarak anlamlı fark yoktu (p> 0,05). Cerrahi alan enfeksiyonu (CAE), intraabdominal apse ve anastomoz kaçağı arasında anlamlı fark vardı (p0.05). Mortalite ve postoperatif ileus arasında anlamlı fark yoktu (p > 0.05).

Sonuç: Elektif KRK nedeniyle ameliyat olmuş hastalarda mekanik kolon temizliği ve antibiyotik uygulamalarının barsak hazırlığı yaklaşımının uygun olduğunu düşünüyoruz.

Anahtar Kelimeler: Kolorektal kanser, bağırsak hazırlığı, cerrahi

Introduction

Although some studies suggest that bacterial colonization in the colon improves the recovery of anastomoses, other research indicates that these bacteria aggravate the situation in cases of potential anastomotic leaking and result in sepsis [1,2]. It is generally known that using antibiotics disturbs both the pathogenic and beneficial bacteria in the intestine, and it takes months for the disrupted intestinal flora to recover. Even with microperforations, harmful microorganisms in the colon can cause diffuse peritonitis and secondary interventions [3].

Without bowel preparation, patients with a high fecal load in the colon get contaminated, and fecal contamination causes postoperative problems ranging from surgical site infections to intra-abdominal sepsis [4]. Colorectal surgery's optimal preoperative bowel preparation regimen is still up for debate. Although some articles demonstrate that elective surgeries performed without any kind of preparation have similar complication rates, especially in trauma patients, it has led to a long period of avoiding bowel preparation, bowel preparation due to fecal contamination has been indicated [5]. While some articles advocate for bowel preparation, other approaches, based on publications on trauma and emergency surgery, do not. Additionally, there are several suggestions made by organizations that recommend bowel preparation, including mechanical bowel preparation (MBP) and/or the use of antibiotics [6].

Additionally, the use of MBP, oral antibiotics (OAB), and intravenous antibiotics (IVAB) is suggested [7]. In this study, we compared four different bowel preparation models (MBP, MBP + OAB, MBP + OAB+ IVAB, control group) of patients who underwent elective surgery for CRC in our clinic to compare the postoperative mortality and morbidity rates.

Material and Methods

The study was carried out in a prospective randomized design. This study comprised 144 patients who underwent elective colorectal cancer surgery in our clinic between 2017 and 2019. Ethical approval was obtained from the local ethics committee (Ref Nr: 2019-115). According to their hospitalization protocol number, the patients were randomly assigned. Depending on the application time, MBP, MBP+OAB, MBP+OAB+IVAB, and control groups were developed, accordingly. In the clinic, four distinct surgical teams carried out the operations. Figure 1 displays a flowchart for the study.

The patients in the MBP group (Group I) (n=35) had two 45 ml sodium phosphate enemas, one 8 hours and one 2 hours before the surgery, as mechanical colon cleansing.

MBP + OAB group (Group II) (n=38) patients had two 45 ml sodium phosphate enemas as mechanical colon cleansing: one 8 hours and one 2 hours before surgery. At 22:00, a 500 mg metronidazole and 1 g ceftriaxone oral tablet were administered as an oral antibiotic.

Preoperatively, the patients in the MBP + OAB + IVAB (Group III) (n=35) group received two 45 ml sodium phosphate enemas as

mechanical colon cleansing: one 8 hours and one 2 hours before surgery. At 2:00, 500 mg of metronidazole and 1 g of ceftriaxone were given orally, and 1 g of ceftriaxone was given intravenously.

The control group (Group IV) (n=36) received no preparation.

The patients in four groups had their demographic information and ASA (American Society of Anesthesiologists) scores analyzed. Patients' mortality rates were documented and compared, along with post-operative anastomotic leakage, wound infection, ileus, intra-abdominal abscess, and rates of ileus.

By performing lower and upper abdomen computed tomography (CT) on patients with defense and/or rebound as well as high CRP and WBC values in the daily physical examination, post-operative anastomotic leakage was identified. Patients with hyperemia and purulent drainage at the incision site were diagnosed with SSI. Patients with no gastric output for 72 hours after surgery, vomiting, and air-fluid level on standing direct abdomen X-ray were diagnosed as post-operative ileus. An intra-abdominal abscess was diagnosed as organized abscess formation in three contrast abdominal CT scans. The 30-day postoperative mortality rate is the number of mortality postsurgical.

The study excluded patients who had emergency surgery for a colorectal tumor. Patients whose colon cleansing or antibiotic treatment was not completed were not included in the study. Patients who underwent surgery for recurring tumors were not included in the investigation. Patients under the age of 18 were not included in the study.

In compliance with the 1964 Helsinki Declaration and its most recent revisions, this study was conducted. Consent was gained from both awake and unconscious patients' first-degree relatives.

Statistical Analysis

Statistical software NCSS 11(Number Cruncher Statistical System, 2017 Statistical Software) was used for the statistical analysis. Continuous variables were given as mean±SD values or median and interquartile ranges and categorical variables were given as frequencies and percentages. The Chi-square test was used when comparing the categorical variables. Where appropriate, categorical variables were evaluated with the Fisher-Freeman Halton test. Kolmogorov Smirnov test used the normal distribution of continuous variables and the Mann-Whitney U test was used for the comparison of nonparametric variables. Statistically significant parameters were compared again in double groups. P values of 0.05 below were accepted as statistically significant.

Results

170 patients were included in the study. 26 patients were excluded from the study. Of these, 14 had ileus, and 5 had tumor perforation and were operated on urgently. Of the 7 patients excluded from the study; 3 were tumor recurrence, 2 were under the age of 18, and 2 were incomplete antibiotic protocol. Of the 144 patients who were operated on for CRC, 73 were female and 71 were male. All patients were operated on electively. There was no statistically significant difference in age (p=0.208) and gender (p=0.987). There were 35 (24.31%) patients in Group I, 38 (26.39%) patients in Group II, 35 (24.31%) patients in Group III, and 36 (25%) patients in Group IV.

Tumor location was observed in 71 patients in the rectum,27 patients in the right colon, 29 patients in the sigmoid colon, and 17 patients in the left colon. There was no significant difference in tumor location between the groups (p=0.503). There was no statistically significant difference in ASA score (p=0.068) between the groups. The demographics and clinical features of patients are shown in Table 1.

Table 1. Demographics and clinical features of patients.

Parameter	Mechanical Bowel Preparation (Group I) (n=35)	Oral Antibiotic and Mechanical Bowel Preparation (Group II) (n=38)	Intravenous Antibiotic, Oral Antibiotic and Mechanical Bowel Preparation (Group III) (n=35)	Control (Group IV) (n=36)	P value
Age (Mean±SD)	60,69±12,4	66,34±10,41	63,77±11,32	64,33±13,55	0,208
Gender ,n(%)					
Female	17 (48,57)	19 (50,00)	18 (51,43)	19 (52,78)	0,987
Male	18 (51,43)	19 (50,00)	17 (48,57)	17 (47,22)	
ASA(Mean±SD)	2,26±0,44	2,5±0,51	2,51±0,56	2,31±0,47	0,068
Tumor location, n(%)					
Rectum	17 (48,57)	15 (39,47)	21 (60,00)	18 (50,00)	0,503
Right colon	4 (11,43)	8 (21,05)	5 (14,29)	10 (27,78)	
Sigmoid colon	9 (25,71)	8 (21,05)	6 (17,14)	6 (16,67)	
Left colon	5 (14,29)	7 (18,42)	3 (8,57)	2 (5,56)	

Anastomotic leaking affected 16 patients (11.11%) (Table 2). There were anastomotic leakage 4 patients in Group I, 1 patient in Group II,1 patient in Group III, and 10 patients in Group IV. There was a significant difference between the groups (p=0.002) (Table 3). In the comparison of the two groups, the difference between the control group and the groups that administered antibiotics (Groups II–III) was statistically significant (p=0.006 and p=0.010, respectively). Between Group I and Group IV, there was no statistically significant difference (p=0,152) (Table 4). There was no statistically significant difference between the 27 (18.75%) postoperative ileus patients and the control group (p=0,165). Ten of the post-operative ileus patients were in Group I, six were in Group II, three were in Group III, and eight were in the control group.

Table 2. Postoperative outcomes of patients

Parameter		n	%
Anastomotic leakage	(-)	128	88,89
	(+)	16	11,11
Post-operative ileus	(-)	117	81,25
	(+)	27	18,75
Intra-abdominal abscess	(-)	130	90,28
	(+)	14	9,72
Surgical site infection	(-)	120	83,33
	(+)	24	16,67
Mortality	(-)	141	97,92
	(+)	3	2,08

Table 3. Outcomes and complications associated with bowel preparation

Parameter	Mechanical Bowel Preparation (Group I)		Oral Antibiotic and Mechanical Bowel Preparation (Group II)		Intravenous Antibiotic, Oral Antibiotic and Mechanical Bowel Preparation (Group III)		Control (Group IV)		P value
	n	%	n	%	n	%	n	%	
Anastomotic leakage	4	11,43	1	2,63	1	2,86	10	27,78	0,002
Post-operative ileus	10	28,57	6	15,79	3	8,57	8	22,22	0,165
Surgical site infection	10	28,57	3	7,89	2	5,71	9	25,00	0,015
Intra-abdominal abscess	5	14,29	1	2,63	1	2,86	7	19,44	0,030
Mortality	1	2,86	0	0	0	0	2	5,56	0,323

Tablo 4. Dual comparison outcomes of groups

Parameter		Group I Group II	GroupI Group III	Group I Group IV	Group II Group III	Group II Group IV	Group III Group IV
Anastomotic leakage	P value	0,306	0,353	0,152	0,510	0,006	0,010
Surgical site infection		0,045	0,026	0,942	0,924	0,090	0,055
Intra-abdominal abscess		0,166	0,200	0,792	0,510	0,051	0,066

Infection at the surgical site affected 24 patients. There were 10 patients in Group I, 9 patients in the control group, and 5 patients in the antibiotic-receiving groups (Groups II to III). The difference in SSI between the groups was statistically significant (p=0.015). Although there was no statistically significant difference between Group I and Group IV (p=0.942), there was a significant difference between Group I and the receiving antibiotic groups (Groups II-III) when comparing the dual groups (p=0.045 and p=0.026, respectively). The intra-abdominal abscess was observed in 5 patients in Group I, 1 patient in Group II,1 patient in Group III, and 7 patients in Group IV. There was a statistically significant difference in intra-abdominal abscesses between the groups (p=0.030). In the double groups' comparison, there was no statistically significant difference between the groups. Three patients died and there was no significant difference in mortality (p=0.323). Of the 3 patients who died, 2 were from Group IV, and 1 was from Group I.

Discussion

Colorectal cancer (CRC) is the third most common cancer in the community. Mortality from CRC accounts for 10% of all cancer deaths [8]. The incidence of CRT is similar in both sexes. Of the

patients included in our study, 71 (49.31%) were male and 73 (50.69%) were female, which is consistent with the literature. In this study, the median age of the patients was 63.84±12.01 and there was no statistically significant difference (p=0.208). It is most common in the literature between 60-75 years of age [9]. The ASA score is the most consistent assessment parameter available. There was no statistically significant difference in ASA score (p=0.068) between the groups. The absence of statistically significant differences in terms of ASA score, age, and gender indicates that the groups in the study were homogeneously distributed in terms of postoperative complications.

Anastomotic leaks following a CRC operation can have devastating effects, often resulting in an increased risk of local recurrence and decreased overall survival in patients [10]. In our study, the overall anastomotic leak rate was 11.11%. Anastomotic leakage was observed in 4 patients in Group I, 1 patient in Group II, 1 patient in Group III, and 10 patients in Group IV (p=0.002). The anastomotic leakage rate was higher in the control group than in the others. In binary comparison, there was a significant difference between Group IV and the receiving antibiotic groups (Group II-III) (p=0.006 and p=0.010, respectively), there was no significant difference between Group I and the receiving antibiotic groups (Group II-III) (p=0.306 and p=0.353, respectively). In addition, there was no statistically significant difference in anastomotic leakage in our analysis between Group I and Group IV (p=0.152). MBP decreases the bacterial load but not the bacterial concentration in the colon [11]. Some studies have consistently failed to demonstrate that MBP alone provides any protection against anastomotic leakage [12,13]. Scarborough et al. [14] stated in their study, the MBP+OAB group and the no prepare group were compared and there was a significant difference (p=0.001). But there was no significant difference between MBP and the no prepare group. Also, Midura et al. [15] stated in their study, the MBP+OAB group and the no prepare group were compared and there was a significant difference (p<0.001). McSorley et al. [16] stated in their study that the İVAB+OAB+MBP group and İVAB+MBP group were compared and there was a significant difference (p<0.001). This meta-analysis underlines that preoperative oral antibiotic prophylaxis, in combination with mechanical bowel preparation and i.v. antibiotic prophylaxis was associated with a significant reduction in rates of anastomotic leakage. But, in our study, there was no significant difference between anastomotic leakage between Group II and Group III (p=0.510). This may be related to the small number of patients in the study sample. We believe that MBP and antibiotics (oral and/or iv) should be used in combination when evaluating our results.

Ileus may develop after surgery in patients undergoing colorectal surgery. This condition determines clinical recovery and therefore contributes to post-operative morbidity. Also, the ileus is a risk factor for anastomotic leakage [17]. In the present study, postoperative ileus was observed in 27 patients in all groups (p=0.165). MBP group had a higher rate than the others. There were mixed results in the literature [18,19].

Hata et al. [18] stated in their study that they found no difference between OAB and İVAB in terms of ileus. According to Garfinkle et al. [19] in their study, they showed that the MBP+OAB group was more effective for ileus but there was no statistically significant difference between MBP and no preparation. No clear consensus is the data regarding post-operative ileus.

Many strategies have been adopted in attempts to reduce SSI (mechanical cleaning, oral/iv antibiotic, and different combinations of these). Mechanical cleaning reduces the fecal load of the colon. It is believed that antibiotics cleanse the intestinal flora. Intestinal flora includes aerobic and anaerobic bacteria. Therefore, we used a combination of metronidazole and ceftriaxone in our study. IV antibiotic prophylaxis has become a standard practice for colorectal surgery, oral antibiotics have not been demonstrated but studies are showing that oral antibiotics reduce SSI [20,21]. The present study indicates that decreased rates of SSI are found in patients who received a mechanical bowel prep combined with antibiotics before elective colorectal surgery. In this study, there was a significant difference in SSI between the MBP group and receiving antibiotics (Group II, Group III) (p=0.045 and p=0.026, respectively). Toh et. al [22] showed that the MBP+OAB group was more effective than the MBP group for SSI. MBP alone has been shown in studies to not affect SSI [23]. In our study, SSI was higher in Group I as well (n=10). In 2018, McSorley et al. [16] revealed that lower SSI was seen in the IVAB+OAB+MBP group (p<0.001). Moreover; in 2018, Kaslow et al. [24] stated that the MBP+OAB group and OAB group were compared, and SSI was significantly reduced in the MBT+OAB group. Our analysis has shown that the addition of IV antibiotics to combined mechanical and oral antibiotic preparation carries the lowest risk concerning SSI development.

Infective complications are an important cause of morbidity and mortality in colorectal surgery. An intra-abdominal abscess is one of them. In the present study, the intra-abdominal abscess was observed in 14 patients. In our

study, receiving antibiotic groups was associated with lower rates of abscess (n=2) and there was a statistically significant difference between the groups (p=0.030) but in double comparison, there was no significant difference between the study groups. In the study of Hata et al. [18], the IV+OAB group was compared with the IV group and no difference was found in terms of an abscess (p=0.465). Moreover, the result of the study is parallel with the experience of the Michigan Surgical Quality Collaborative Colectomy Project by Kim et al [25]. in 2014. In the study, 1914 patients were compared. The study demonstrates that patients who received oral antibiotics and MBP had fewer organ space infections than those who did not have bowel preparations. Our analysis has shown that there is no benefit in the use of MBP and no preparation. Although there was no significant difference in double comparisons, our results suggest that more benefit was achieved with a combination of antibiotic (oral±iv) + MBP.

There was no difference between the groups in terms of mortality (p=0.323). No mortality had been when taking antibiotics in the study. Whereas different results are seen in some studies published in the literature [16,19]. McSorley et al.[16] showed that mortality was significantly lower in the İVAB + OAB + MBP group than in the İVAB + MBP group (p<0.001). Also, Garfinkle et al. [19] found a difference in MBP and no preparation groups in dual comparisons (like OAB and no preparation, MBP+OAB and no preparation).

Our study had several limitations. The major limitation of our study is the small number of patients. Apart from this, the inclusion of all patients who underwent laparoscopic and open surgery in our study and the fact that the surgery was performed by four different teams may have caused a limitation in terms of standardization.

In conclusion, we think that antibiotic and mechanical bowel cleansing should be done together as a perioperative cleaning model. There is a need for further studies with larger series on the subject.

Conflict Of Interests

All authors declare no competing interests.

Sources Of Funding

The author(s) received no specific funding for this work.

Authorship Contributions

Conceptualization (BK, MAB); data curation and formal analysis (BK, MAB, CS); interpretation of data (BK, MAB); statistical analysis (BK, MAB, CS); writing – draft (BK, MAB, CS); writing – review and editing of manuscript (BK, MAB, CS); final approval (all authors).

References

1. Konishi T, Watanabe T, Kishimoto J, Nagawa H. Risk factors for anastomotic leakage after surgery for colorectal cancer: results of prospective surveillance. J Am Coll Surg 2006; 202: pp. 439-444.
2. Hunt TK, Hawley PR. Surgical judgement and colonic anastomoses. Dis Colon Rectum 1969; 12:167-71.
3. Cannon JA, Altom LK, Deierhoi RJ, et al. Preoperative oral antibiotics reduce surgical site infection following elective colorectal resections. Dis Colon Rectum 2012;55(11):1160–1166.
4. Nichols RL , Condon RE. Preoperative preparation of the colon. Surg Gynecol Obstet 1971;132:323–337.
5. Biondo S, Jaurrieta E, Jorba R, et al. Intra-operative colonic lavage and primary anastomosis in peritonitis and obstruction. Br J Surg 1997; 84: pp. 222-225.
6. Ambe P.C. , Zarras K. , Stodolski M. , Wirjawan, I. , Zirngibl H. Routine preoperative mechanical bowel preparation with additive oral antibiotics is associated with a reduced risk of anastomotic leakage in patients undergoing elective oncologic resection for colorectal cancer. World J of Surg Oncol. 2019;17(1): 20.
7. Murray AC , Kiran RP. Bowel Preparation: Are Antibiotics Necessary for Colorectal Surgery? Adv Surg. 2016 Sep;50(1):49-66.
8. Gönen Ö. Kolorektal kanser epidemiyolojisi. Kolorektal Özel Sayısı. Türkiye Klinikleri J of Surg 2004;9:11-14.
9. Eddy DM. Screening for colorectal cancer. Ann Intern Med. 1990; 113:373.
10. Hammond J, Lim S, Wan Y, Gao X, Patkar A. The burden of gastrointestinal anastomotic leaks: An evaluation of clinical and economic outcomes. J Gastrointest Surg 2014;18:1176–1185.
11. Nichols RL, Condon RE, Gorbach SL, Nyhus LM. Efficacy of preoperative antimicrobial preparation of the bowel. Ann Surg. 1972;176:227–232.
12. Fry DE. Colon preparation and surgical site infection. Am J Surg. 2011;202:225–232.
13. Slim K, Vicaut E, Launau-Savary MV, Contant C, Chipponi C. Updated systematic review and meta-analysis of randomized clinical trials on the role of mechanical bowel preparation before colorectal surgery. Ann Surg. 2009;249:203–209.
14. Scarborough JE, Mantyh CR, Sun Z, Migaly J. Combined mechanical and oral antibiotic bowel preparation reduces incisional surgical site infection and anastomotic leak rates after elective colorectal resection. Ann Surg 2015;262:331–337.

15. Midura EF, Jung AD, Hanseman DJ, et al. Combination oral and mechanical bowel preparations decreases complications in both right and left colectomy. Surgery. 2018;163:528-534.
16. McSorley ST, Steele CW, McMahon AJ. Meta-analysis of oral antibiotics, in combination with preoperative intravenous antibiotics and mechanical bowel preparation the day before surgery, compared with intravenous antibiotics and mechanical bowel preparation alone to reduce surgicalsite infections in elective colorectal surgery. BJS Open. 2018;2:185-194.
17. Kang CY, Halabi WJ, Chaudhry OO, et al. Risk factors for anastomotic leakage after anterior resection for rectal cancer. JAMA Surg 2013; 148: 65–71.
18. Hata H, Yamaguchi T, Hasegawa S, Nomura A, et al. Oral and parenteral versus parenteral antibiotic prophylaxis in elective laparoscopic colorectal surgery (JMTO PREV 07-01): a phase 3, multicenter, open-label, randomized trial. Ann Surg 2016; 263: 1085–1091.
19. Garfinkle R, Abou-Khalil J, Morin N, et al. Is there a role for oral antibiotic preparation alone before colorectal surgery? ACS-NSQIP analysis by coarsened exact matching. Dis Colon Rectum 2017; 60: 729–737.
20. Nichols RL, Smith JW, Garcia RY, Waterman RS, Holmes JW. Current practices of preoperative bowel preparation among North American colorectal surgeons. Clin Infect Dis Off Publ Infect Dis Soc Am 1997:24(4):609–619.
21. Gillespie G, McNaught W. Prohylactic oral metronidazole in intestinal surgery. J Antimicrob Chemother 1978:4 Suppl C:29–32.
22. Toh JWT, Phan K, Hitos K, et al. Association of mechanical bowel preparation and oral antibiotics before elective colorectal surgery with surgical site infection: a network meta-analysis. JAMA Netw Open 2018; 1: e183226.
23. Koller SE, Bauer KW, Egleston BL, et al. Comparative effectiveness and risks of bowel preparation before elective colorectal surgery. Ann Surg 2018; 267: 734–732.
24. Kaslow SR, Gani F, Alshaikh HN, Canner JK. Clinical outcomes following mechanical plus oral antibiotic bowel preparation versus oral antibiotics alone in patients undergoing colorectal surgery. BJS open. 2018;2(4):238–245.
25. Kim EK, Sheetz KH, Bonn J, et al. A statewide colectomy experience: The role of full bowel preparation in preventing surgical site infection. Ann. Surg. 2014;259:310–314.