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# Mechanical and oral antibiotic bowel preparation in ovarian cancer debulking: Are we lowering or just trading surgical complications?☆

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## HIGHLIGHTS

- MOABP prior to bowel resection at ovarian cancer CRS was associated with lower deep/organspace SSI and readmissions.
- MOABP prior to bowel resection was associated with higher odds of ICU admissions and grade ≥ 3 cardiac and GI complications.
- MOABP prior to bowel resection may be associated with shorter hospital stays and more optimal resections.

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## ABSTRACT

*Objectives.* To examine postoperative complications associated with preoperative mechanical and oral antibiotic bowel preparation (MOABP) for patients with ovarian cancer who underwent bowel resection at cytoreductive surgery (CRS).

*Methods.* This was a single-institution retrospective study of patients with ovarian cancer undergoing CRS from 01/2011–12/2020 using ICD-10 diagnoses and procedure codes. Patients were stratified by those who underwent bowel resection versus no resection. Bowel resection patients were further stratified by those who underwent MOABP versus no bowel preparation. Patient demographics, tumor data, and perioperative metrics were collected. Unadjusted and adjusted logistic regression evaluated odds of 30-day postoperative complications in patients with bowel resection versus no resection and those with MOABP versus no bowel preparation.

*Results.* Of 919 patients identified, 215 (23.3%) required bowel resection, which included 81 (37.7%) who received MOABP. Patient characteristics, co-morbidities, and cancer data were similar between MOABP versus no bowel preparation patients. MOABP patients underwent more interval CRS (34.6% versus 9.0%), more optimal surgical resections (96.3% versus 83.8%), fewer diverting ostomies (13.5% versus 33.5%), and shorter hospital stays (7.1 versus 9.4 days) than no bowel preparation patients. On adjusted analyses, MOABP patients experienced significantly lower odds of deep/organ-space surgical infections and 30-day readmissions but higher odds of unplanned intensive care unit (ICU) admissions and grade 3 or higher cardiac and gastrointestinal complications.

*Conclusions.* Patients who underwent preoperative MOABP prior to ovarian cancer CRS with bowel resection had lower odds or deep/organ-space infections and readmissions, shorter hospital stays, fewer diverting ostomies, and more optimal resections. However, these patients also experienced higher odds of ICU admissions and grade 3 or higher cardiac and gastrointestinal complications. The positive and negative postoperative outcomes in this population should be considered in clinical practice.



## 1. Introduction

The role of preoperative bowel preparation is debated across many surgical specialties including gynecology and gynecologic oncology [1–10]. Several studies have shown that mechanical bowel preparation (MBP) alone confers no significant postoperative advantages when compared to no preparation at all [3,8,11–13]. Moreover, MBP is associated with significant patient discomfort [14,15] and can cause adverse

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physiologic changes [1,9]. However, in recent years, there has been a resurgence in the use of bowel preparation. Database and retrospective studies, mainly from colorectal surgery literature, have demonstrated that the combination of mechanical and oral antibiotic bowel preparation (MOABP) leads to reductions in surgical site infections (SSI), anastomotic leaks, and other health outcomes such as hospital readmissions and length of hospital stay [3–7,15–18].

In gynecology and gynecologic oncology, most evidence regarding bowel preparation is extrapolated from colorectal literature [1,2,19]. Although gynecology and gynecologic oncology guidelines discourage the use of MBP prior to surgery, the use of MOABP remains controversial [1,2,9,19]. In the American College of Obstetrician and Gynecologists Committee Opinion 750 (reaffirmed in 2020) for Enhanced Recovery After Surgery (ERAS) pathways [19], its authors encouraged shared decision-making regarding MOABP administration in cases where bowel surgery may be anticipated. Similarly, in the 2019 update by the ERAS Society for gynecologic oncology, routine use of MOABP is discouraged but can be considered in cases where bowel resection is planned [2]. More data regarding MOABP use is needed, particularly for gynecologic oncologists who perform cytoreductive surgeries (CRS) for advanced ovarian cancers, as most surgeries are done by laparotomy and bowel resections are common and often required to achieve optimal or complete surgical resection in order to improve survival [1,20]. Additionally, patients who undergo CRS with bowel resection may be elderly, malnourished, and have widespread peritoneal-based disease that place them at high risk for postoperative physiologic derangements, infections, and organ-system complications [20,21]. An international survey of perioperative practice in surgeons performing gynecologic oncology surgeries revealed that, although approximately 80% of respondents prescribed bowel preparation when potential bowel surgery was anticipated, the majority still used MBP [22]. Additional data regarding MOABP administration in the gynecologic oncology setting is warranted to guide clinical practice.

At our institution, preoperative MOABP is uniformly recommended by the multidisciplinary infection control team for both colorectal and gynecologic oncology surgery services. Additionally, to unify practices, MOABP use before CRS was adopted in 2017 by the gynecologic oncology service if the surgeon anticipates a bowel resection. Before 2017, the use of MOABP in gynecologic oncology was based solely on surgeon discretion. We hypothesized that, despite an anticipated lowering of SSI rates, the dehydration and subsequent physiologic derangements caused by MOABP may worsen surgical outcomes in this cohort of patients undergoing bowel resection at CRS. Our primary outcome was to examine differences in postsurgical complications and the odds of developing postsurgical complications in patients with ovarian cancer undergoing CRS that required bowel resection, specifically comparing those who used MOABP to the patients who did not have a bowel preparation.

## 2. Methods

### 2.1. Ethics statement

This study was approved by the Institutional Review Board (IRB#19042) at the University of Wisconsin School of Medicine and Public Health.

### 2.2. Data collection

This study was a single-institution retrospective observational cohort study. Patients were identified by ICD-10 codes for ovarian, fallopian, or primary peritoneal cancer within our institution's database from 1/1/2011 to 12/31/2020. Inclusion criteria were all ovarian cancer patients who underwent CRS. Exclusion criteria were insufficient operative or post-operative data and no follow-up data within 30 days of surgery. Study start date was chosen to coincide with the start of our institutional database collection. Study end date was chosen for the logistics of data collection, verification, and maturation.

All patients with ovarian cancer undergoing CRS were stratified into those who underwent a bowel resection and those who did not. The patients who underwent a bowel resection were further stratified into those who had a preoperative MOABP and those who did not have a bowel preparation.

At our institution, all patients who were recommended for preoperative bowel preparation were prescribed MOABP. For MOABP, the MBP portion was comprised of either polyethylene glycol bowel preparation or magnesium citrate, and the oral antibiotic (OA) regimen included neomycin and metronidazole.

Medical records were abstracted for patient data and clinical characteristics. Patient characteristics included age, body mass index (BMI), medical co-morbidities, Eastern Cooperative Oncology Group (ECOG) performance status (PS), and American Society of Anesthesiologist (ASA) score. Clinical characteristics included tumor stage, grade, and histology, as well as surgical data, which included the surgery type (primary or interval), residual disease, creation of diverting bowel ostomy, estimated blood loss (EBL), duration of surgery, and length of hospital stay.

Thirty-day postsurgical outcomes were abstracted from the medical records. These included the number of patients who required postoperative blood transfusions, unplanned intensive care unit (ICU) admissions, reoperations during the same surgical admission, and the number of patients who experienced: any grade 3 or higher (G ≥ 3) complications for each body system (graded according to Clavien-Dindo classification) [23], any SSI (superficial and deep/organ-space), G ≥ 3 venous thromboembolism (VTE), G ≥ 3 pulmonary, cardiac, and gastrointestinal (GI) complications, 30-day readmissions, and 30-day mortalities. All abstracted data, including postsurgical outcomes, were collected from our institution's medical records and from affiliated or outside institutions via our electronic medical record's data sharing platform (Epic Systems Corporation's Care Everywhere) or scanned-in media.

Our primary objective was to assess differences in 30-day postsurgical complications between MOABP use compared to no bowel preparation in patients with ovarian cancer who needed bowel resection at CRS.

We also included descriptive data, data on surgical complications, and the odds ratios of developing complications for patients who underwent bowel resection at CRS and those who did not. These data were important to include because, by demonstrating the morbidity associated with bowel resection at CRS for ovarian cancer in our patient cohort, we provide context to understand the postsurgical outcomes related to MOABP use.

### 2.3. Statistics

The patients' primary and baseline characteristics were reported using descriptive statistics for the entire cohort, as well as for the subgroups that included those who had bowel resection versus no bowel resection at CRS and those who had MOABP and bowel resection versus no bowel preparation and bowel resection at CRS. The outcomes were categorized into present or absent. Categorical variables were summarized as counts and percentages and tested by Chi-square or Fisher's exact tests for variables containing less than five subjects. Continuous variables were summarized as means with standard deviations or medians with interquartile ranges based on variable distributions, and they were tested by *t*-test or Kruskal-Wallis tests.

Univariate and multivariable Cox proportional hazards regression models were performed, and odds ratios (OR) with 95% confidence intervals (CI) were calculated to further elucidate the relationship between MOABP and the surgical complications. We utilized propensity weighting due to the small number of events. All statistical tests were two-sided with 5% ($P < 0.05$) as the level of significance. All statistical analyses were done in R version 3.4.2 or later (R Core Team, 2014).

## 3. Results

### 3.1. Demographics

A total of 919 patients with ovarian cancer who underwent CRS during the study period met criteria for inclusion. Of the 919 patients, 215 (23.4%) patients required a bowel resection at CRS. Among patients who had a bowel resection, 81 (37.6%) had a preoperative MOABP (Fig. 1).

Patient characteristics for all 919 patients are described in Table 1. Overall, patients had a mean age of 60.9 years and mean BMI of 29.1 kg/m2 at the time of CRS. Most patients were classified with an ASA score ≤ 2 (87.8%) and an ECOG PS ≤ 1 (95.4%). The most common comorbid condition was hypertension (38.6%). Regarding tumor characteristics, most patients had at least International Federation of Gynecologic and Obstetrics (FIGO) stage IIIA to IVB cancers [24], papillary serous histology, and grade 3 tumors. The majority presented for primary CRS (73.7%) with 63.4% achieving complete surgical resection and 28.2% undergoing optimal resection (≤1 cm of residual disease). At time of CRS, 6.1% of patients underwent a diverting ostomy formation. Average length of hospital stay was 6.1 days.

### 3.2. Bowel resection versus no bowel resection

Patient characteristics, tumor data, and surgery metrics between those who required bowel resection at CRS (215, 23.4%) and those who did not (704, 76.6%) are shown in Table 1. Compared to no bowel resection, patients who underwent bowel resection were significantly older (62.7 vs 60.3 years, $p = 0.009$), had lower BMI (28.1 vs 29.3 kg/m2, $p = 0.043$), and had more patients with ECOG PS of 2 to 3 (7.4% vs 3.6%, $p = 0.041$). More patients requiring bowel resection presented with at least stage IIIA cancers (95.9% vs 83.0%, $p < 0.001$), papillary serous histology (88.3% vs 73.9%, $p < 0.001$), and grade 3 tumors (88.8% vs 81.3%, $p = 0.040$). These patients also had fewer tumors with endometrioid (1.4% vs 11.2%, $p < 0.001$) and clear cell (3.7% vs 8.0%, $p = 0.031$) histology.

Patients who had bowel resection underwent significantly more primary CRS (81.4% vs 71.3%, $p = 0.001$) than those who did not have a bowel resection. These patients also had more diverting ostomies formed (26.2% vs 0%, $p < 0.001$), longer surgeries (4.3 vs 3.92 h, $p = 0.010$), and longer hospital stays (8.2 vs 4.8 days, $p = 0.025$). There were no differences in EBL, the rate of optimal resections, or in the number of days to the first cycle of adjuvant chemotherapy after primary CRS and after interval CRS.

On logistic regression (Table 2), the unadjusted model showed that patients who had a bowel resection at CRS experienced higher odds of unplanned ICU admissions, all SSI, and deep/organ-space SSI than those who did not have a bowel resection. After adjusting for significant differences between the two groups (age, ECOG PS, tumor stage, tumor histology, tumor grade, surgery type [primary CRS versus interval CRS], diverting ostomy formed, and duration of surgery), patients who underwent bowel resection had statistically significant higher odds of unplanned ICU admissions (OR 2.20, 95% CI 1.30–4.20), all SSI (OR 1.98, 95% CI 1.10–2.40), and specifically deep/organ-space SSI (OR 4.8, 95% CI 1.90–10.50). There were no differences in VTE, pulmonary, cardiac, or GI complications. Thirty-day readmissions and mortality were also similar, and there was only one 30-day mortality in the cohort who did not have a bowel resection. (Table 2, S1 contains the forest plot).

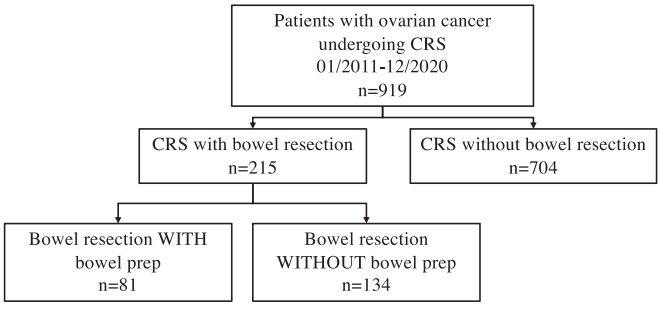


**Fig. 1.** Screening flow chart.
Legend: CRS = cytoreductive surgery.

### 3.3. Bowel resection with preoperative MOABP versus bowel resection without bowel preparation

Of the 215 patients who had a bowel resection, 81 (37.6%) had a bowel resection with preoperative MOABP and 134 (62.3%) did not have a bowel preparation. There were no differences in patients' demographic characteristics and their medical co-morbidities (Table 3). More patients who had MOABP prior to bowel resection had undergone interval CRS (34.6% vs 9.0%, $p < 0.001$) and achieved more optimal surgical resections at CRS (96.3% vs 84.3%, $p = 0.001$) than those who did not have a bowel preparation. Those who had MOABP had significantly fewer diverting ostomies formed at CRS (13.5% vs 33.5%, $p = 0.003$), shorter surgeries (3.74 vs 4.21 h, $p = 0.010$), and shorter hospital stays (7.1 vs 9.4 days, $p = 0.025$). There were no differences in days to adjuvant chemotherapy initiation between patients who received or did not receive MOABP prior to bowel resection at CRS (28 days vs 27 days, $p = 0.100$).

On logistic regression (Table 4), the unadjusted model showed that patients who had preoperative MOABP prior to bowel resection at CRS experienced significantly lower odds of deep/organ-space infections (OR 0.13, 95% CI 0.02–0.69) and 30-day readmissions (OR 0.16, 95% CI 0.04–0.72). However, these patients had significantly higher odds of unplanned ICU admissions (OR 2.20, 95% CI 1.07–4.70), cardiac complications (OR 7.20, 95% CI 1.49–34.90), and GI complications (OR 4.40, 95% CI 1.51–13.20).

Upon adjusting for all significant differences between the two groups (surgery type [primary CRS versus interval CRS], residual disease, diverting ostomy formed, and duration of surgery), the significant differences in surgical outcomes seen on unadjusted analyses persisted (Table 4). Patients who had MOABP experienced significantly lower odds of deep/organ-space infections (OR 0.33, 95% CI 0.24–0.89) and 30-day readmissions (OR 0.29, 95% CI 0.11–0.87), but they had significantly higher odds of unplanned ICU admissions (OR 1.87, 95% CI 1.10–3.80), cardiac complications (OR 4.20, 95% CI 1.02–12.50), and GI complications (OR 2.80, 95% CI 1.21–4.50) (Table 4).

After adjusting, there were no differences in perioperative transfusions, reoperations, number of patients with G ≥ 3 complications, all or superficial SSI, VTE, and pulmonary complications. No 30-day mortalities were seen in any patients in either group. (Fig. 2).

Of patients who had MOABP prior to bowel resection at CRS, the most common reason for unplanned ICU admissions was hypotension requiring vasopressors or inotropes. The most common reason for cardiac complications was tachycardia and the most common reason for GI complications was ileus. Of patients who did not have bowel preparation and underwent bowel resection at CRS, the most common reasons for unplanned ICU admissions and cardiac complications were the same as those who had MOABP. The most common reason for GI complications in patients who had no bowel preparation was high ostomy output (Table 4).

## 4. Discussion

Bowel resection at ovarian cancer CRS is common [20], and this was demonstrated in our study as well. Regardless of bowel preparation, patients in this study who underwent bowel resection at CRS experienced significantly higher morbidity than those who did not. Unsurprisingly, patients who underwent bowel resection had more cancers with

**Table 1**
Patient characteristics, cancer data, and surgical data for all patients and those who underwent bowel resection versus no bowel resection at cytoreductive surgery.

| | | Total, $n = 919$ | CRS with bowel resection, $n = 215$ | CRS without bowel resection, $n = 704$ | *P*-value |
|---|---|---|---|---|---|
| n (%) | | 919 (100.0%) | 215 (23.4%) | 704 (76.6%) | |
| Patient characteristics | | | | | |
| Age (years), mean (SD) | | 60.9 (11.9) | 62.7 (1.6) | 60.3 (12.0) | **0.009** |
| BMI (kg/m2), mean (SD) | | 29.1 (7.7) | 28.1 (7.4) | 29.3 (7.7%) | **0.043** |
| Diabetes, n (%) | | 114 (12.4%) | 23 (10.7%) | 91 (12.9%) | 0.390 |
| HTN, n (%) | | 335 (38.6%) | 80 (37%) | 275 (39.1%) | 0.590 |
| COPD, n (%) | | 49 (5.3%) | 9 (4.2%) | 40 (5.7%) | 0.390 |
| Heart failure, n (%) | | 15 (1.6%) | 1 (0.5%) | 14 (2.0%) | 0.130 |
| CAD, n (%) | | 32 (3.5%) | 6 (2.8%) | 26 (3.7%) | 0.520 |
| Altered mentation, n (%) | | 14 (1.5%) | 1 (0.5%) | 13 (1.8%) | 0.169 |
| CVA/TIA, n (%) | | 24 (2.6%) | 2 (0.9%) | 22 (3.1%) | 0.070 |
| Functional status, n (%) | | | | | **0.041** |
| | 0–1 | 877 (95.4%) | 199 (92.6%) | 679 (96.4%) | |
| | 2–3 | 41 (4.6%) | 16 (7.4%) | 25 (3.6%) | |
| ASA (#), n (%) | | | | | 0.690 |
| | 1–2 | 807 (87.8%) | 187 (87.4%) | 620 (88.1%) | |
| | 3–4 | 111 (12.1%) | 28 (13.1%) | 83 (11.8%) | |
| Cancer Data | | | | | |
| Stage, n (%) | | | | | **<0.001** |
| | IA - IIB | 196 (21.3%) | 9 (4.1%) | 120 (17.0%) | |
| | IIIA - IVC | 723 (78.6%) | 206 (95.9%) | 584 (83.0%) | |
| Histology, n (%) | | | | | |
| | Papillary serous | 709 (77.1%) | 189 (88.3%) | 520 (73.9%) | **<0.001** |
| | Endometrioid | 83 (9.0%) | 4 (1.4%) | 79 (11.2%) | **<0.001** |
| | Undifferentiated | 29 (3.2%) | 3 (1.4%) | 26 (3.7%) | 0.090 |
| | Clear cell | 64 (7.0%) | 8 (3.7%) | 56 (8.0%) | **0.031** |
| | Other | 34 (3.7%) | 11 (5.1%) | 23 (3.2%) | 0.190 |
| Grade, n (%) | | | | | |
| | 1 | 92 (10.0%) | 17 (7.9%) | 75 (10.7%) | 0.200 |
| | 2 | 61 (6.6%) | 7 (3.3%) | 54 (7.7%) | 0.170 |
| | 3 | 762 (82.9%) | 190 (88.8%) | 572 (81.3%) | **0.040** |
| Surgery Data | | | | | |
| Surgery type, n (%) | | | | | **0.001** |
| | Primary CRS | 677 (73.7%) | 175 (81.4%) | 502 (71.3%) | |
| | Interval CRS | 239 (26.0%) | 40 (18.6%) | 201 (28.5%) | |
| Residual disease, n (%)[a] | | | | | 0.057 |
| | ≤1 cm | 842 (91.6%) | 191 (88.8%) | 651 (92.5%) | |
| | >1 cm | 77 (8.3%) | 24 (11.2%) | 53 (7.5%) | |
| Diverting ostomy formed, n (%) | | 56 (6.1%) | 56 (26.2%) | 0 | **<0.001** |
| EBL (mililetes), mean (SD) | | 589 (574) | 556 (550) | 603 (590) | 0.280 |
| Duration of surgery (hours), mean (SD) | | 4.1 (1.47) | 4.30 (1.30) | 3.92 (1.50) | **0.010** |
| Length of hospital stay (days), mean (SD) | | 6.1 (4.3) | 8.2 (5.5) | 4.8 (3.5) | **0.025** |
| Adjuvant chemotherapy initiation after surgery (days), mean (SD) | | 27 (8) | 27 (6) | 26 (8) | 0.100 |
| | Post-primary CRS | 31 (7) | 32 (7) | 31 (8) | 0.100 |
| | Post-interval CRS | 24 (8) | 25 (8) | 24 (7) | 0.070 |

Legend: SD = standard deviation; BMI = body mass index; HTN = hypertension, COPD = chronic obstructive pulmonary disease; CAD = coronary artery disease, CVA/TIA = cerebral vascular accident/transient ischemic attack; EBL = estimated blood loss; CRS = cytoreductive surgery.
[a] Comparison of patients with microscopic and ≤ 1 cm of residual disease vs those with >1 cm of disease.

advanced stage, papillary serous histology, and grade 3 tumors. These patients also had poorer functional statuses and more of them presented for primary CRS, underwent higher number of diverting ostomies, and had longer average hospital stays by approximately three days. Further, these patients experienced significantly higher odds of unplanned ICU admissions, all SSI, and deep/organ-space SSI. These findings are consistent with prior studies demonstrating significantly higher odds of SSI in patients undergoing bowel surgery for ovarian cancer CRS [20]. As institutions continue to promote protocols to lower SSI and perioperative complications, especially for surgeries where bowel resection may be anticipated, the use of MOABP and its potential addition to SSI prevention bundles should be investigated.

In our study, preoperative MOABP in patients with ovarian cancer who underwent a CRS that required a bowel resection was associated with significantly lower odds of deep/organ-space SSI and 30-day readmissions. These patients also experienced higher rates of optimal surgical resections, less diverting ostomy formations, shorter duration of surgeries, and shorter average hospital stays by approximately two days. However, preoperative MOABP was also associated with significantly higher odds of unplanned ICU admissions, G ≥ 3 cardiac complications, and G ≥ 3 GI complications after bowel resection at CRS. Findings from our study add to the sparse body of literature regarding the use of MOABP in gynecologic surgery.

The interesting finding that a higher percentage of patients achieved optimal surgical resection if they underwent MOABP prior to bowel resection at CRS is notable because residual disease is one of the most important prognostic indicators for survival in ovarian cancer [25]. This can be potentially explained by our finding that MOABP patents who underwent a bowel resection at CRS were more likely to have undergone interval CRS than patients who did not have a bowel preparation. Another reason may be due to selection bias. Surgeons may be more inclined to prescribing bowel preparation for healthier patients who can withstand more radical CRS. They may also offer bowel preparation to patients for whom the surgeons feel confident about their ability to

**Table 2**
Regression models of patients who underwent bowel resection versus no bowel resection at cytoreductive surgery.

| | n (%) | | Unadjusted | Adjusted[a] |
|---|---|---|---|---|
| | CRS with bowel resection (n = 215) | CRS without bowel resection (n = 704) | OR (95% CI) Ref = No bowel resection | OR (95% CI) Ref = No bowel resection |
| **Outcomes** | | | | |
| Perioperative blood transfusion, n (%) | 69 (32.1%) | 277 (39.3%) | 0.72 (0.52–1.01) | 0.82 (0.61–1.23) |
| Unplanned ICU admission, n (%) | 33 (15.3%) | 31 (4.4%) | **3.93 (2.30–6.60)** | **2.20 (1.30–4.20)** |
| Reoperation during the same admission, n (%) | 1 (0.5%) | 5 (0.7%) | 0.65 (0.08–5.62) | 0.73 (0.12–4.50) |
| Patients with G ≥ 3 complications, n (%) | 53 (24.7%) | 327 (46.4%) | **0.37 (0.26–0.53)** | 0.87 (0.56–1.50) |
| Surgical site infection, n (%) | | | | |
| All | 17 (7.9%) | 26 (3.7%) | **2.23 (1.10–2.50)** | **1.98 (1.05–2.40)** |
| Superficial | 4 (1.8%) | 17 (2.4%) | 0.76 (0.25–2.30) | 0.86 (0.45–1.98) |
| Deep / Organ-space | 13 (6.0%) | 9 (1.3%) | **4.90 (2.0–11.7)** | **4.80 (1.90–10.50)** |
| VTE, n (%) | 3 (1.4%) | 10 (1.4%) | 0.98 (0.26–3.6) | 1.10 (0.36–3.20) |
| Pulmonary complications, n (%) | 12 (5.6%) | 32 (4.5%) | 1.24 (0.62–2.45) | 1.10 (0.76–2.10) |
| Cardiac complications, n (%) | 10 (4.7%) | 27 (3.8%) | 1.22 (0.58–2.56) | 1.32 (0.76–1.90) |
| GI complications, n (%) | 17 (7.9%) | 45 (6.4%) | 1.25 (0.71–2.24) | 1.32 (079–1.80) |
| 30-day readmissions | 20 (9.3%) | 77 (10.9%) | 0.88 (0.52–1.47) | 0.90 (0.68–1.30) |
| 30-day mortality | 0 | 1 (0.4%) | 1.10 (0.44–26.8) | 1.10 (0.45–15.8) |

Legend: ICU = intensive care unit; G ≥ 3 = grade 3 or higher complication; VTE = venous thromboembolism, GI = gastrointestinal; CRS = cytoreductive surgery; OR = odds ratio; CI = confidence interval; Ref = reference.

[a] Adjustment made for relevant differences in Table 1: age, functional status, stage, histology, grade, surgery type (primary CRS vs interval CRS), diverting ostomy formed, and duration of surgery.

achieve an optimal surgical resection. Our study was not powered to examine mortality data, and future studies with larger patient sizes should validate our findings, given the pivotal role residual disease play in survival after ovarian cancer CRS.

Regarding diverting ostomy formations, diverting ostomies are sometimes created in patients undergoing bowel resection for whom there are high risks for anastomotic leaks. This practice is controversial. Some studies have shown the protective value of diverting ostomies in lowering rates of sepsis [26], but other studies have failed to show a protective impact on post-operative complications [27]. Short-term outcomes of diverting ostomies include higher rates of readmission [28] and dehydration [26,28]. Long-term outcomes include up to a 37% chance of not being able to reverse the ostomies [28] as well as poor patient-related quality of life [29], although most of the reported poor quality indicators are related to complications like para-stomal hernias and not just due to the existence of the ostomy. Our results showed that those who had MOABP prior to bowel resection at CRS had fewer diverting ostomies formed than patients who had no bowel preparation. This finding may be in part explained by the significantly higher number of patients who underwent interval CRS in the MOABP and bowel resection cohort.

In our institution, an SSI prevention bundle was implemented in our gynecologic oncology service in 2015. S2 described our SSI prevention bundle. In brief, it included timely administration of preoperative weight-based systemic antibiotics with appropriate redosing interval, 4% chlorhexidine gluconate shower the night before and the morning of surgery, 2% chlorhexidine gluconate skin preparation prior to incision with appropriate dry time and application technique, maintenance of normothermia and normoglycemia perioperatively, and appropriate postoperative care of the incision. In the 2019 update to the ERAS society guidelines for gynecologic oncology [2], its authors discouraged the use of routine MOABP before open laparotomy cases. They cited data suggesting that an SSI reduction bundle without bowel preparation already leads to comparatively lower rates of SSI in high-risk gynecologic surgeries than those seen in colorectal surgery patients. Indeed, although our overall SSI rate of 4.3% in all patients undergoing CRS regardless of bowel resection was slightly higher than seen with contemporary gynecologic literature [2,21], it was markedly lower than reported rates in colorectal surgery patients [4–7,10,15–18]. However, even with an already low SSI rate, we still found lower odds of deep/organ-space SSI with the use of preoperative MOABP prior to bowel resection. These results are consistent with the reported findings from Lippit et al., [21] in which their authors found that, after implementing an SSI bundle that included MOABP, there was a significant decrease in all SSI from 33% to 7% for patients with ovarian cancer who underwent colon resections at CRS. We were not able to control for our institution's implementation of the SSI prevention bundle in our study. However, the clinical implications of our findings are that MOABP prior to bowel resection in ovarian cancer CRS appears to be associated with a striking improvement in serious postoperative SSI. Future studies that can adjust for the implementation of SSI reduction bundles may further inform MOABP's effect in decreasing SSI in this population.

Major criticisms regarding mechanical bowel preparation relate to not just the pain, distension, fatigue, and nausea imposed on patients but also the adverse physiologic effects [30–32]. Metabolic disturbances related to bowel preparation can mostly be attributed to the profound dehydration experienced by patients. These can lead to serum electrolyte derangements, metabolic acidosis, and postoperative complications [30–32]. In the first prospective randomized trial done that compared MOABP with no bowel preparation before elective colon resections, Koskenvuo et al. found that SSI rates were similar between both groups with no difference in cumulative postoperative complications or in overall postoperative morbidity [33]. Importantly, close to 80% of their cohort underwent laparoscopic surgery. This is different than our population of patients who mostly undergo laparotomy for CRS, which inherently portends a higher risk of SSI and perioperative morbidity [25]. Alternatively, bowel preparation with oral antibiotic alone has been studied, which remains controversial. Multiple studies have found conflicting conclusions regarding its use for SSI prevention or for reducing postoperative complications [1,2,4,6,34]. In our study of patients using preoperative MOABP, we reported higher odds of unplanned ICU admissions and grade 3 or higher cardiac and GI complications after MOABP than those who did not have a bowel preparation prior to bowel resection at CRS. These findings are troubling because, although the physiologic effects of bowel preparation may not be as clinically concerning in healthy patients [30]. the risks are accentuated in older and frailer patients, such as our patients with advanced ovarian cancers [1,21]. We additionally found no difference in the number of days to initiation of adjuvant chemotherapy between patients who underwent MOABP and those with did not prior to bowel resection at CRS. This finding is interesting, as it suggests that the postoperative complications patients experienced did not negatively affect the timing of chemotherapy

**Table 3**
Patient characteristics, cancer data, and surgical data for all patients and those who underwent bowel resection with bowel preparation vs. bowel resection without bowel preparation.

| | | Bowel resection WITH Bowel preparation | Bowel resection WITHOUT bowel preparation | P-value |
|---|---|---|---|---|
| n (%) | | 81 (37.6%) | 134 (62.3%) | |
| Patient characteristics | | | | |
| Age (years), mean (SD) | | 64 (12.1) | 61.9 (10.6) | 0.200 |
| BMI (kg/m2), mean (SD) | | 27.9 (7.8) | 28.3 (7.1) | 0.710 |
| Diabetes, n (%) | | 13 (16%) | 10 (7.5%) | 0.051 |
| HTN, n (%) | | 32 (39.5%) | 48 (35.8%) | 0.580 |
| COPD, n (%) | | 2 (2.5%) | 7 (5.2%) | 0.330 |
| Heart failure, n (%) | | 0 | 1 (0.7%) | 0.450 |
| CAD, n (%) | | 4 (4.9%) | 2 (1.5%) | 0.142 |
| Altered mentation, n (%) | | 0 | 1 (0.7%) | 0.450 |
| CVA/TIA, n (%) | | 0 | 2 (1.5%) | 0.260 |
| Functional status, n (%) | | | | 0.230 |
| | 0–1 | 78 (96.3%) | 121 (89.5%) | |
| | 2–3 | 3 (3.7%) | 13 (10.5%) | |
| ASA (#), n (%) | | | | 0.290 |
| | 1–2 | 68 (84.0%) | 119 (88.9%) | |
| | 3–4 | 13 (16.0%) | 15 (11.1%) | |
| Cancer Data | | | | 0.640 |
| Stage, n (%) | | 4 (4.9%) | 5 (3.7%) | |
| | IA - IIB | 77 (95.1%) | 129 (96.3%) | |
| | IIIA - IVC | | | 0.510 |
| Histology, n (%) | | | | |
| | Papillary serous | 73 (90.1%) | 116 (86.6%) | |
| | Endometrioid | 2 (1.5%) | 2 (1.5%) | |
| | Undifferentiated | 1 (1.2%) | 2 (1.5%) | |
| | Clear cell | 5 (6.2%) | 3 (2.2%) | |
| | Other | 0 | 11 (8.2%) | |
| Grade, n (%) | | | | 0.690 |
| | 1 | 8 (9.9%) | 9 (6.7%) | |
| | 2 | 1 (1.2%) | 6 (4.5%) | |
| | 3 | 72 (88.9%) | 118 (88%) | |
| Surgery Data | | | | |
| Surgery type, n (%) | | | | **<0.001** |
| | Primary CRS | 53 (65.4%) | 122 (91.0%) | |
| | Interval CRS | 28 (34.6%) | 12 (9.0%) | |
| Residual disease, n (%)[a] | | | | **0.001** |
| | ≤1 cm | 78 (96.3%) | 113 (84.3%) | |
| | >1 cm | 3 (3.7%) | 21 (15.6%) | |
| Diverting ostomy formed, n (%) | | 11 (13.5%) | 45 (33.5%) | **0.003** |
| EBL (mililiter), mean (SD) | | 503 (341) | 588 (640) | 0.200 |
| Duration of surgery (hours), mean (SD) | | 3.74 (1.3) | 4.21 (1.27) | **0.010** |
| Length of hospital stay (days), mean (SD) | | 7.1 (3.2) | 9.4 (2.9) | **0.025** |
| Adjuvant chemotherapy initiation after surgery (days), mean (SD) | | 28 (5) | 27 (4) | 0.100 |
| | Post-primary CRS | 33 (6) | 32 (5) | 0.180 |
| | Post-interval CRS | 26 (7) | 24 (9) | 0.088 |

Legend: SD = standard deviation; BMI = body mass index; HTN = hypertension, COPD = chronic obstructive pulmonary disease; CAD = coronary artery disease, CVA/TIA = cerebral vascular accident/transient ischemic attack; EBL = estimated blood loss; CRS = cytoreductive surgery.
[a] Comparison of patients with microscopic and ≤ 1 cm of residual disease vs those with >1 cm of disease.

initiation after primary or interval CRS. This may be explained by timely recognition and management of bowel preparation-related complications, and it underscores the importance for gynecologic oncologists to remain cognizant of the physiologic effects that may ensue after preoperative MOABP use.

Our study provides gynecologic oncologists important information regarding the use of MOABP in patients with ovarian cancer undergoing CRS who have a high risk of needing a bowel resection. Our study had many strengths. Our institution is a high-volume surgical center for ovarian cancer, and this study included a large sample of patients with ovarian cancer who underwent CRS during the study timeframe. We further conducted analyses on all patients and no exclusions were done for the sake of data selection. This provided us power to assess detailed characteristics and use adjusted regression models. Weaknesses to our study included the inherent biases related to retrospective studies, and some surgeons may not have fully adhered to the preoperative use of MOABP. However, an internal quality review audit found that our institution met a preset 75% quality benchmark item that assessed proper MOABP prescription for whom it is indicated prior to surgery.

Although our study controlled for many factors relevant for evaluating postsurgical outcomes, we did not specifically measure the preoperative frailty of our patients, and this remains a potential metric to include in future studies. The numbers of postoperative complications were relatively small, which led us to conduct multivariate analyses with propensity matching. Weighted multivariable analyses were used and should be interpreted with caution as the level of statistically significant findings may change if we would have had more complications. Further, we reported 30-day postsurgical morbidity and mortality in our study; future studies should investigate more extended periods of morbidity and mortality data. This study spanned 10 years and we could not account for changes in surgical practices due to implementation of ERAS protocols. Lastly, we could not verify that the patients who were prescribed bowel preparations fully adhered to the MOABP regimen. Therefore, we could not exclude the possibility of important variations in how much of the MOABP patients were able to complete. Large prospective studies or randomized clinical trials that can account for this significant confounding factor and the other limitations are warranted.

**Table 4**
Regression models of patients who underwent MOABP prior to bowel resection versus no bowel preparation prior to bowel resection at cytoreductive surgery.

| | n (%) | | Unadjusted | Adjusted[a] |
|---|---|---|---|---|
| | Bowel resection WITH bowel preparation ($n = 81$) | Bowel resection WITHOUT bowel ($n = 134$) | OR (95% CI) Ref= No bowel preparation | OR (95% CI) Ref= No bowel preparation |
| **Outcomes** | | | | |
| Perioperative blood transfusion, n (%) | 31 (38.3%) | 38 (28.4%) | 1.56 (0.87–2.80) | 1.43 (0.92–1.84) |
| Unplanned ICU admission, n (%) | 18 (22.2%) | 15 (11.2%) | **2.20 (1.07–4.70)** | **1.87 (1.10–3.80)** |
| Most common reason | Hypotension[b], 11 (13.6%) | Hypotension[b], 8 (6.0%) | | |
| Reason 2 | DIC, 2 (2.5%) | Difficulty extubating, 2 (1.5%) | | |
| Reoperation during the same admission, n (%) | 1 (1.2%) | 0 | 5.00 (0.21–12.50) | 4.2 (0.35–8.50) |
| Patients with G ≥ 3 complications, n (%) | 21 (25.9%) | 32 (23.9%) | 1.11 (0.56–2.10) | 1.05 (0.69–1.75) |
| Surgical site infection, n (%) | | | | |
| All | 8 (9.9%) | 9 (6.7%) | 1.52 (0.56–4.11) | 1.32 (0.68–2.80) |
| Superficial | 2 (2.5%) | 2 (1.5%) | 1.67 (0.23–12.10) | 1.52 (0.43–6.50) |
| Deep / Organ-space | 1 (1.2%) | 12 (8.9%) | **0.13 (0.02–0.69)** | **0.33 (0.24–0.89)** |
| VTE, n (%) | 2 (1.5%) | 2 (1.5%) | 1.67 (0.23–12.10) | 1.52 (0.56–4.80) |
| Pulmonary complications, n (%) | 7 (8.6%) | 5 (3.7%) | 2.44 (0.74–7.90) | 1.84 (0.84–3.50) |
| Cardiac complications, n (%) | 8 (9.9%) | 2 (1.5%) | **7.20 (1.49–34.90)** | **4.20 (1.02–12.50)** |
| Most common reason | Tachycardia[c], 5 (6.2%) | Tachycardia[c], 1 (0.7%) | | |
| Reason 2 | Demand ischemia, 1 (1.2%) | Demand ischemia, 1 (0.7%) | | |
| Reason 3 | ADHF, 1 (1.2%) | | | |
| Reason 4 | Pericardial tamponade, 1 (1.2%) | | | |
| GI complications, n (%) | 12 (14.8%) | 5 (3.7%) | **4.40 (1.51–13.20)** | **2.80 (1.21–4.50)** |
| Most common reason | Ileus[d], 7 (8.6%) | High ostomy output[e], 6 (4.5%) | | |
| Reason 2 | High ostomy output[e], 3 (3.7%) | Ileus[d], 3 (2.2%) | | |
| Reason 3 | Anastomotic leak, 1 (1.2%) | Anastomotic leak, 2 (1.5%) | | |
| 30-day readmissions | 2 (2.4%) | 18 (13.4%) | **0.16 (0.04–0.72)** | **0.29 (0.11–0.87)** |
| 30-day mortality | 0 | 0 | | |

Legend: ICU = intensive care unit; G ≥ 3 = grade 3 or higher complication; VTE = venous thromboembolism, GI = gastrointestinal; CRS = cytoreductive surgery; DIC = disseminated intravascular coagulopathy; ADHF = acute decompensated heart failure; OR = odds ratio; CI = confidence interval; Ref = reference.

[a] Adjustment made for relevant differences from Table 3: Surgery type (primary CRS vs interval CRS), residual disease diverting ostomy formed, duration of surgery.

[b] Hypotension defined as low blood pressures that required pharmacologic management with vasopressors or inotropes.

[c] Tachycardia defined as tachycardia that needed pharmacologic intervention and additional work up including computed tomography and/or echocardiography without identification of organic causes and without elevations in cardiac enzymes.

[d] Ileus defined as prolonged return of bowel function >5 days.

[e] High ostomy output defined as >2.5 l per day for more than 3 days and required interventions.

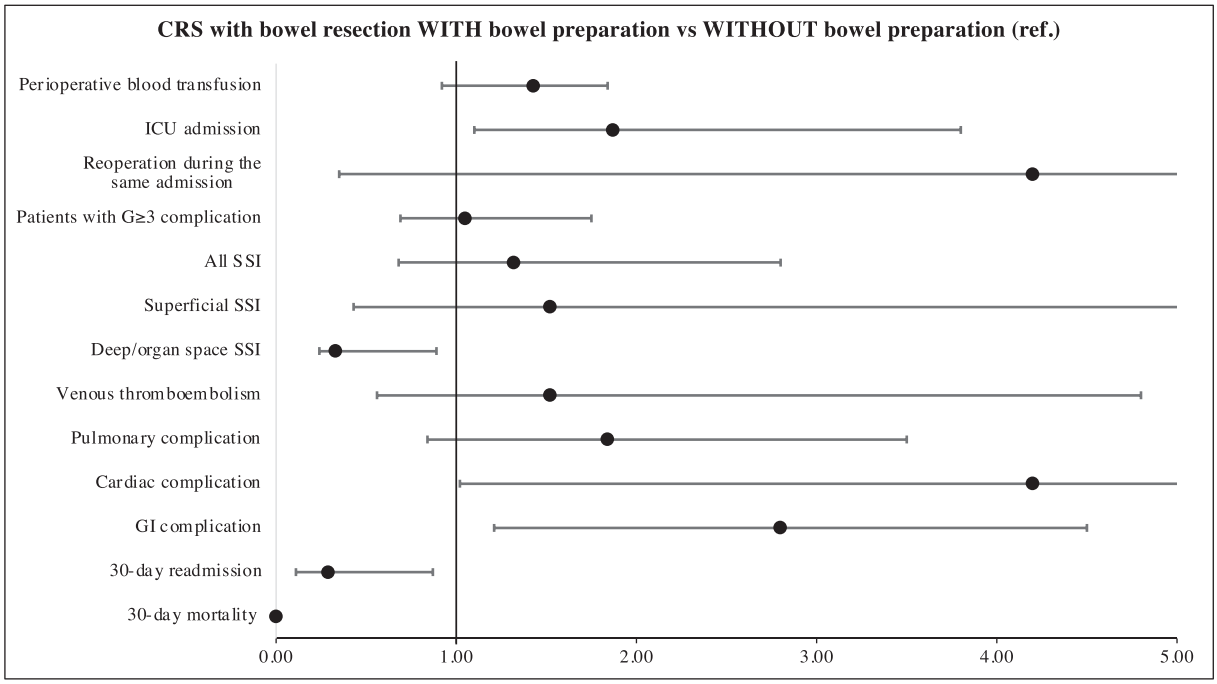


**Fig. 2.** Forest plot of the adjusted analysis of patients who underwent MOABP prior to bowel resection versus no bowel preparation prior to bowel resection at CRS.
Legend: MOABP = combined mechanical bowel preparation and oral antibiotics; ICU = intensive care unit; G ≥ 3 = grade 3 or higher complication; SSI = surgical site infection; GI = gastrointestinal; CRS = cytoreductive surgery; ref. = reference.

The use of MOABP in patients with ovarian cancer undergoing a CRS that required bowel resection appears to be associated with lower odds of SSI and 30-day readmissions. Patients also have shorter hospital stays and more optimal surgical resections. However, these patients also saw increased odds of experiencing unplanned ICU admissions and grade 3 or higher cardiac and GI complications. Given the significant differences in surgical complications experienced by patients who used MOABP and those who did not prior to bowel resection at CRS, we advocate for system-level discussions about MOABP administration and for surgeons to consider each patient's comorbid conditions regarding the potential advantages and disadvantages of MOABP in patients with ovarian cancer at high risk for bowel surgery at CRS. Large prospective gynecologic oncology studies examining MOABP use in similar patient populations that are powered to examine survival and patient factors associated with postoperative complications are warranted.

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None.

## CRediT authorship contribution statement

**Connor C. Wang:** Conceptualization, Methodology, Formal analysis, Writing – original draft. **Rana Al-Rubaye:** Writing – review & editing. **Vienna Tran:** Writing – review & editing. **Lauren Montemorano:** Writing – review & editing. **Ahmed Al-Niaimi:** Conceptualization, Methodology, Data curation, Formal analysis, Writing – review & editing.

## Declaration of Competing Interest

The authors do not have any conflicts of interest to disclose.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ygyno.2022.05.007.

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