Preoperative oral antibiotic bowel preparation in elective resectional colorectal surgery reduces rates of surgical site infections: a single-centre experience with a cost-effectiveness analysis

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ABSTRACT

INTRODUCTION Surgical site infections cause considerable postoperative morbidity and mortality. The aim of this study was to determine the effect on surgical site infection rates following introduction of a departmental oral antibiotic bowel preparation protocol.

METHODS A prospective single-centre study was performed for elective colorectal resections between May 2016–April 2018; with a control group with mechanical bowel preparation and treatment group with oral antibiotic bowel preparation (neomycin and metronidazole) and mechanical bowel preparation. The primary outcome of surgical site infection and secondary outcomes of anastomotic leak, length of stay and mortality rate were analysed using Fisher's exact test and independent samples *t*-tests. A cost-effectiveness analysis was also performed.

RESULTS A total of 311 patients were included; 156 in the mechanical bowel preparation group and 155 in the mechanical bowel preparation plus oral antibiotic bowel preparation group. The study included 180 (57.9%) men and 131 (42.1%) women with a mean age of 68 years. There was a significant reduction in surgical site infection rates (mechanical bowel preparation 16.0% vs mechanical bowel preparation plus oral antibiotic bowel preparation 4.5%; $P = 0.001$) and mean length of stay (mechanical bowel preparation 10.2 days vs mechanical bowel preparation plus oral antibiotic bowel preparation 8.2 days; $P = 0.012$). There was also a reduction in anastomotic leak and mortality rates. Subgroup analyses demonstrated significantly reduced surgical site infection rates in laparoscopic resections ($P = 0.008$). There was an estimated cost saving of £239.13 per patient and £37,065 for our institution over a one-year period.

CONCLUSION Oral antibiotic bowel preparation is a feasible and cost-effective intervention shown to significantly reduce the rates of surgical site infection and length of stay in elective colorectal surgery.

KEYWORDS

Colorectal surgery – Antibiotics – Surgical site infection

Accepted 30 June 2019

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Introduction

Surgical site infections are a major cause of postoperative morbidity and mortality, responsible for up to 16% of all healthcare-associated infections.¹ The incidence of surgical site infections with colorectal surgery is considerably higher, accounting for 15–30% of cases.² There is a multifactorial association with older age, comorbid status, longer operative times and the nature of a clean-contaminated operative field. The US Centers for Disease Control and Prevention (CDC) defines a surgical site infection as a healthcare-associated infection with pathological microorganisms populating a surgical wound.^{1,3} A surgical site infection is considered to be a potentially preventable postoperative

complication and risk assessments are thus performed to identify process targets to improve overall patient outcomes and reduce healthcare costs.

The use of oral antibiotic bowel preparation (OABP) has been evolving since the 1970s when Nichols *et al* introduced OABP with mechanical bowel preparation (MBP), successfully demonstrating a reduction in surgical site infection rates from 43% to 9%.⁴ Since then, various infection prevention bundles have been proposed, implemented and evaluated, resulting in reduced surgical site infection rates, supported by multiple randomised controlled trials and a Cochrane review.^{5–7} However, there is no consensus on antibiotic choice and regimen.

The American Society of Colon and Rectal Surgeons and Society of American Gastrointestinal and Endoscopic Surgeons have published guidelines recommending the use of combined OABP and MBP.⁸ The use of OABP is now routine practice in the United States, where much of the current evidence has emerged, and is yet to be adopted in the UK and European guidelines. The current National Institute of Health and Care Excellence (NICE) guidelines advise against the routine use of MBP because of insufficient evidence; the guidelines do not comment on the use of OABP.⁹

The aim of this study was to observe the change in surgical site infection rates in elective colorectal surgery after introduction of a local protocol combining OABP and MBP compared with MBP alone.

Materials and methods

Identifying the problem

Ipswich Hospital NHS Trust routinely records major colorectal surgery cases, their associated 30-day complications and preoperative risk factors in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP®) database. This programme provides risk-adjusted outcomes for hospital performance.¹⁰ It also allows direct comparison with peer hospitals around the world, the majority being in North America. Critical evaluation of the data revealed that our department had higher rates of surgical site infections following colorectal surgery than our peer hospitals. We reviewed factors contributing to surgical site infections, both surgery and patient related. There were no obvious deviations from standard surgical practices among the departmental surgeons, including the use of surgical preparation (chlorhexidine), intravenous antibiotic choice on induction (commonly gentamicin and metronidazole,

and occasionally co-amoxiclav) and preoperative mechanical bowel preparation (prescribed according to local established protocol).

There was no clear theme in patient-related factors such as current smoking status, body mass index and associated comorbidities. We therefore systematically searched for current recommendations and evidence-based practice which could improve our clinical outcomes. There is a wealth of evidence from randomised controlled trials and large retrospective reviews supporting the use of OABP prior to elective colorectal resections. Our review revealed that neomycin, a non-absorbable oral antibiotic, was the antibiotic of choice, followed by erythromycin and metronidazole (Table 1). We discussed potential concerns regarding *Clostridium difficile* colitis rates with the microbiologists, and a review of the literature demonstrated no increased risk with OABP.^{11,12} The pharmacological antibiotic adverse-effect profile was also considered in negotiation with the pharmacists. After addressing these concerns, a departmental protocol for the use of OABP was established by a collaborative team involving consultant general and colorectal surgeons, colorectal specialist nurses, surgical specialist nurses and pharmacists, and was introduced in April 2017.

Study design

A quasi-experimental prospective cohort study was conducted at the colorectal unit at a single district general hospital between May 2016 and April 2018. The preintervention group receiving MBP included consecutive patients undergoing elective colorectal resections over a one-year period. Patients undergoing right-sided resections were advised to follow a low-residue diet and those undergoing left-sided resections were advised to follow a clear-fluid diet with MBP consisting of three sachets of Klean-Prep®

Table 1 Published oral antibiotic regimens for oral antibiotic bowel preparation.

	Neomycin	Erythromycin	Metronidazole	Kanamycin	Duration (days)
Hata <i>et al</i> (2016) ¹¹			750mg BD	1g BD	1
Ingraham <i>et al</i> (2009) ²¹	1g TDS	1g TDS			1
Lewis (2002) ²²	2g BD		2g BD		1
Wren <i>et al</i> (2005) ²³	1g TDS	1g TDS			1
Espin-Basany <i>et al</i> (2005) ²⁴	1g TDS		1g TDS		1
Ishida <i>et al</i> (2001) ⁵			400mg QDS	500mg QDS	2
Kaiser <i>et al</i> (1983) ¹⁹	1g TDS	1g TDS			1
Coppa and Eng (1988) ²⁵	1g TDS	1g TDS			1
Lau <i>et al</i> (1988) ²⁶	1g TDS	1g TDS			1
Peruzzo <i>et al</i> (1987) ²⁷	1g TDS				1
Reynolds <i>et al</i> (1989) ²⁸	1g TDS		400mg TDS		2
Stellato <i>et al</i> (1990) ²⁹	1g TDS	1g TDS			1

BD, twice daily; QDS, four times daily; TDS, three times daily.

(Norgine, Harefield) to be taken on the day prior to surgery. From April 2017 onward, all patients received additional oral antibiotic bowel preparation in the form of three doses each of 1g neomycin and 400mg metronidazole on the preoperative day. After introduction of the OABP to the same MBP protocol, post-interventional data collection continued for a further year for consecutive patients undergoing elective colorectal resections. All other factors remained constant.

Patient data collection

The complete ACS-NSQIP colorectal targeted dataset was recorded, including patient demographics and numerous other preoperative characteristics with the potential to affect postoperative surgical site infection rates. Variables included body mass index, age, smoking status, comorbidities, American Society of Anesthesiologists grade, cancer diagnoses, diabetes, use of immunosuppressants, preoperative serum albumin ($< 35\text{g/l}$), use of blood transfusion preoperatively and surgical approach (open, laparoscopic, laparoscopic converted to open). Patients were excluded if the surgery was not elective or if there was evidence of intraperitoneal contamination. Strict criteria to diagnose a surgical site infection were followed in both cohorts as per the CDC definition to avoid bias: a superficial/deep and organ space infection occurs after the operation involving either the skin/subcutaneous tissue of the incision, or an area other than the incision site; respectively. This is associated with one of the following: (a) purulent drainage with or without laboratory confirmation; (b) organisms isolated from fluid or tissue culture; (c) signs or symptoms of infection (pain, localised swelling, redness, heat, wound deliberately opened); or abscess involving organ space found on examination, reoperation or radiologically; (d) diagnosis by a clinician.⁵ All information was collected by review of the notes, searches on electronic hospital information systems, questionnaires sent to patients and telephone interviews with patients. Data was entered by specifically trained and certified ACS-NSQIP surgical case reviewers.

Outcomes measures

The primary outcome was the overall incidence of surgical site infection (superficial, deep, or organ space) within 30 days of surgery. Secondary outcomes were anastomotic leak, mortality rate and length of hospital stay. A risk-adjusted trend view of surgical site infection rates in colorectal operations for our department was provided by ACS-NSQIP.

Statistical analysis

Patient data were extracted from the ACS-NSQIP database and analysed using SPSS Statistics, version 22. Dichotomous data were presented as a number alongside a percentage of the total, and parametric data presented as a mean with a range and standard deviation (SD). The baseline patient data were analysed between both groups to confirm comparability between groups and to identify any possible confounders. Fisher's exact test was used to

analyse categorical variables and Student's independent samples *t*-test for continuous variables. Univariate analysis was used to identify an association between the use of OABP and the postoperative complications. Subsequent multivariate regression analysis provided risk-adjusted outcome measures. A subset analysis was performed to compare the outcomes in patients undergoing open or laparoscopic procedures. All tests were two-sided, and a *P*-value of less than 0.05 was considered statistically significant.

A cost-effectiveness analysis was performed using the observed effect on surgical site infection and length of hospital stay after implementation of this new protocol in our institution. NICE estimates surgical site infection costs, including costs for extended hospital stays, range between £2,100 and £10,500 per infection, but as high as £20,000 for complex surgery and £14,000 for more general surgery.¹⁵ We chose the conservative NICE estimate of £2,100 per surgical site infection. Our institutional costs for neomycin were 42 pence per 500-mg tablet and metronidazole 1.6 pence per 400-mg tablet. The total additional cost for 1g neomycin and 400-mg metronidazole three times a day each was £2.57 per patient in the intervention group. These figures were used for a cost-effectiveness analysis.

Results

The study included 311 consecutive patients, with 156 patients in the preintervention control group receiving MBP only, followed by 155 patients receiving combined OABP and MBP (Table 2). There was a preponderance towards men, at 57.9% (180/311), and an average age of 68.5 years (age range 16–94 years; SD 13.4). The majority of primary diagnoses were malignant colorectal tumours, most commonly sigmoid or rectal tumours (MBP 45.6% vs MBP + OABP 42.6%), followed by caecal or ascending colon tumours (MBP 30.1% vs MBP + OABP 30.9%). Benign pathologies included colitis and diverticular disease complicated by fistulae to surrounding organs. There were comparable numbers of types of colorectal operations, both open and laparoscopic approaches, across both groups. Operations were consistent with the primary diagnoses; the most common open procedures were a right hemicolectomy (12.2% vs 12.9%) and anterior resection with or without ileostomy (10.9% vs 12.9%). Similarly, the most common laparoscopic approaches were an anterior resection with or without ileostomy (25.6% vs 26.5%) and right hemicolectomy (24.4% vs 27.7%).

Risk factors affecting surgical site infection rates were considered: baseline patient characteristics were similar across both cohorts, including additional risk factors such as body mass index, current smoking status and pathological diseases such as cancer, diabetes and the use of immunosuppressive agents (Table 3). Only preoperative serum albumin levels and the presence of chronic kidney disease were significantly different between both groups. Subsequent analyses were therefore risk adjusted for these two preoperative parameters.

Table 2 Patient demographics and baseline characteristics.

Variable ^a	MBP only group (n = 156)	MBP + OABP group (n = 155)	P-value (exploratory)
Age (years)	68.3 (20–94) SD 13.2	68.7 (16–89) SD 13.6	0.772
Sex:			0.384
Male	70 (44.9%)	61 (39.4%)	
Female	86 (55.1%)	94 (60.6%)	
Current smoker:			0.857
No	141 (90.4%)	142 (91.6%)	
Yes	15 (9.6%)	13 (8.4%)	
Body mass index (kg/m ²)	27.8 (16.8–59.3) SD 5.8	28.1 (17.7–56.2) SD 5.5	0.627

^a Continuous variables reported as mean (range) and standard deviation. Discrete variables reported as frequency (percentage). MBP, mechanical bowel preparation; OABP, oral antibiotic bowel preparation.

Table 3 Preoperative risk factors.

Risk factor	MBP only group (n = 156) n (%)	MBP + OABP group (n = 155) n (%)	P-value (exploratory)
Immunosuppression:			0.987
No	144 (92.3)	142 (91.6)	
Yes	12 (7.7)	13 (8.4)	
Diabetes:			0.534
No	131 (84.0)	135 (87.)	
Yes	25 (16.0)	20 (12.9)	
Cancer:			0.977
No	32 (20.5)	33 (21.3)	
Yes	124 (79.5)	122 (78.7)	
Chronic kidney disease:			0.029
No	142 (91.0)	127 (81.9)	
Yes	14 (9.0)	28 (18.1)	
Serum albumin (g/l)			0.035
< 35	131 (84.0)	114 (73.5)	
> 35	25 (16.0)	41 (26.5)	
Preoperative red blood cell transfusion:			0.374
No	143 (91.7)	147 (94.8)	
Yes	13 (8.3)	8 (5.2)	

ASA grade:			0.322
1	22 (14.1)	18 (11.6)	
2	96 (61.5)	86 (55.5)	
3	34 (21.8)	48 (31.0)	
4	4 (2.6)	3 (1.9)	
Cardiovascular comorbidity:			0.953
No	75 (48.1)	73 (47.1)	
Yes	81 (51.9)	82 (52.9)	
Respiratory comorbidity:			0.859
No	131 (84.0)	128 (82.6)	
Yes	25 (16.0)	27 (17.4)	
Neurological comorbidity:			0.450
No	151 (96.8)	153 (98.7)	
Yes	5 (3.2)	2 (1.3)	
Endocrine comorbidity:			0.999
No	141 (90.4)	140 (90.3)	
Yes	15 (9.6)	15 (9.7)	
Gastrointestinal comorbidity:			0.748
No	135 (86.5)	137 (88.4)	
Yes	21 (13.5)	18 (11.6)	
Surgical approach:			0.570
Laparoscopic	103 (66.0)	108 (69.7)	
Open	53 (34.0)	47 (30.3)	

MBP, mechanical bowel preparation; OABP, oral antibiotic bowel preparation.

Surgical site infection

The overall incidence of surgical site infection was 16% (25/156) in the MBP group and 4.5% (7/155) in the MBP + OABP group (Table 4). This represents a significant reduction in surgical site infection following the introduction of MBP + OABP, with a risk-adjusted odds ratio (AOR) of 0.224 (95% confidence interval, CI, 0.092 to 0.546; $P = 0.001$). This was particularly evident for superficial surgical site infections, which showed a reduction from 10.5% to 2.6% (AOR 0.227; 95% CI 0.073 to 0.707; $P = 0.011$). Additionally, there was a reduction in organ space infections, although not achieving statistical significance, from 7.1% to 3.2% (AOR 0.382; 95% CI 0.126 to 1.160; $P = 0.089$). No deep surgical site infections were observed in either group. There was negligible reduction in cases of anastomotic leak between the two groups, with three cases (1.9%) in the MBP group and two cases (1.3%) in the MBP + OABP group ($P = 0.642$).

Table 4 Univariate association between additional oral antibiotic bowel preparation and postoperative complications, risk-adjusted against chronic kidney disease and serum albumin class prior to operation.

Complication	MBP only group (n = 156)	MBP+OABP group (n = 155)	Adjusted NNT ^a	Adjusted OR (95% CI)	P-value
Surgical site infections, n (%):	25 (16.0)	7 (4.5)	8.4	0.224 (0.092, 0.546)	0.001
Superficial	16 (10.3)	4 (2.6)	12.9	0.227 (0.073, 0.707)	0.011
Organ space	11 (7.1)	5 (3.2)	23.6	0.382 (0.126, 1.160)	0.089
Anastomotic leak, n (%)	3 (1.9)	2 (1.3)	149.6	0.648 (0.104, 4.041)	0.642
<i>Clostridium difficile</i> colitis, n (%)	0	0	–	–	–
Ileus, n (%)	16 (10.3)	18 (11.6)	(210.0)	1.052 (0.507, 2.184)	0.892
Urinary tract infection, n (%)	11 (7.1)	6 (3.9)	26.0	0.437 (0.152, 1.258)	0.125
Chest infection, n (%)	10 (6.4)	13 (8.4)	(83.6)	1.202 (0.501, 2.883)	0.680
Mortality, n (%)	3 (1.9)	1 (0.6)	72.9	0.283 (0.028, 2.894)	0.287
Postoperative length of hospital stay (days), mean (SD)	10.2 (10.4)	–	–	Beta –2.46 (–4.375, –0.541)	0.012

^a Risk-adjusted number needed to treat (NNT) for benefit (number needed to treat for harm).
CI, confidence interval; MBP, mechanical bowel preparation; OABP, oral antibiotic bowel preparation; OR, odds ratio; SD, standard deviation.

Length of hospital stay

The mean non-adjusted postoperative length of stay was 10.2 days (range 3–98 days; SD 10.4) in the MBP group and shorter at 8.2 days (range 2–39 days; SD 6.1) in the MBP + OABP group. After risk adjustment, our analysis demonstrates a significant reduction in expected length of stay by 2.46 days with the addition of OABP (95% CI –4.375 to –0.541; $P = 0.012$). There was no significant difference between the length of stay for those patients who developed a surgical site infection across both groups (17.9 days MBP group vs 16.4 days in the MBP + OABP group; $P = 0.84$).

Other postoperative complications

Infectious complications unrelated to the operation site, such as chest and urinary tract infections, had no significant association with the use of OABP ($P = 0.680$ and $P = 0.125$). There was a slightly increased rate of reported ileus from 10.3% (16/156) to 11.6% (18/155); however, this was not statistically significant ($P = 0.892$). We had no reported cases of *C. difficile* infection in either group. Thirty-day mortality reduced from three patients in the MBP group to one in the MBP + OABP group, but no statistical significance could be ascribed due to low numbers.

Subgroup analysis

A subgroup analysis was performed for open and laparoscopic approaches (Table 5). Overall, there were 211 laparoscopic procedures (103/156 vs 108/155) and 100 open procedures (53/156 vs 47/155), with similar numbers between the groups. Twenty-eight cases were converted from a laparoscopic to open approach (15 in the MBP group, 13 in the MBP + OABP group). We observed a reduction in surgical site infection rates in laparoscopic

approaches from 12.6% (13/103) to 0.9% (1/108), which was statistically significant ($P = 0.008$). In particular, there was a significant reduction in superficial surgical site infection (7.8% vs 0.9%; $P = 0.041$). Although organ-space infections in the laparoscopic approach were reduced from 4.9% to 0.9% this was not statistically significant ($P = 0.105$) in this study. In the open approach, the number of surgical site infection cases halved (12/53 vs 6/47), but this was not enough to reach statistical significance ($P = 0.200$).

Cost-effectiveness analysis

Using the average surgical site infection costs of £2,100 as published by NICE, the estimated cost was £52,500 (£336.54 per patient) and £14,700 (£94.84 per patient) for the control group and intervention group, respectively. After considering the cost of the intervention at £2.57 per patient, a total of £239.13 was saved per patient. The saving to our institution over a one-year period was estimated at £37,065.

Discussion

Our prospective study supports the combined use of neomycin and metronidazole alongside MBP by showing the effective reduction of surgical site infections. Our primary outcome was the incidence of surgical site infection rates in patients undergoing elective colorectal resections, and we have demonstrated a highly significant reduction in overall surgical site infections and superficial surgical site infections, together with a non-significant reduction for organ-space infections. The long-term trend of risk-adjusted surgical site infection rates in colorectal resections provided by ACS-NSQIP for our department

Table 5 Subgroup analysis by approach (open compared with laparoscopic) for outcomes of surgical site infections, risk-adjusted against chronic kidney disease and serum albumin class prior to surgery.

Complication	MBP only group	MBP+OABP group	Adjusted NNT ^a	Adjusted OR (95% CI)	P-value
<i>Laparoscopic approach:</i>	(N = 103)	(N = 108)			
Surgical site infections, <i>n</i> (%):	13 (12.6)	1 (0.9)	8.1	0.061 (0.008, 0.482)	0.008
Superficial	8 (7.8)	1 (0.9)	14.6	0.111 (0.013, 0.916)	0.041
Organ space	5 (4.9)	1 (0.9)	24.8	0.163 (0.018, 1.460)	0.105
<i>Open approach:</i>	(N = 53)	(N = 47)			
Surgical site infections, <i>n</i> (%):	12 (22.6)	6 (12.8)	9.6	0.475 (0.152, 1.482)	0.200
Superficial	8 (15.1)	3 (6.4)	11.4	0.378 (0.087, 1.648)	0.196
Organ space	6 (11.3)	4 (36.0)	36.0	0.732 (0.178, 3.008)	0.666

Figure 1 Five-year trend of departmental surgical site infection rate in colorectal operations. The arrow indicates when the oral antibiotic bowel preparation protocol was introduced (error bars, 95% confidence intervals, yellow line, surgical site infection rate in peer group hospitals). Source: ACS-NSQIP database.

documented that the introduction of OABP had made our department comparable in that respect to our peer group hospitals (Fig 1). The increasing use of OABP has led to the implementation of surgical site infection prevention bundles simultaneously addressing several potential factors contributing to surgical site infections. Surgical site infection prevention bundles are based on literature and best practice to standardise practice within a hospital trust. Within our department, many components of such bundles are already standard practice, including 2% chlorhexidine skin preparation, the use of intravenous antibiotics on induction and use of a wound protector. As a department, we therefore decided to address the concern of elevated

surgical site infection rates with the introduction of OABP alone.

Klinger *et al* reviewed 27,804 patients and concluded that combined OABP and MBP was more effective in reducing rates of surgical site infections, anastomotic leaks, wound dehiscence, *C. difficile* and length of hospital stay in comparison with using either preparation alone.^{14,15} With robust evidence from the Cochrane systematic reviews and multiple randomised controlled trials, the use of OABP is routine practice in many healthcare systems around the world.⁵⁻⁷ Morris *et al* analysed the ACS-NSQIP database on elective colorectal resections (*n* = 8415) and showed that OABP decreased surgical site infection rates by 54% (95%

CI 41–64%) compared with no preparation and 46% compared with MBP only.¹⁶ This study also showed a 50% decrease in anastomotic leak rate with OABP. Kim *et al* supported this further with a level 3 study on elective patients ($n = 2475$) showing how MBP + OABP decreased surgical site infection rates from 9.7% to 5% ($P < 0.001$) compared with no preparation.¹⁷ Although the use of OABP with MBP is gaining momentum globally, there is debate regarding the benefits of OABP alone. Although supported by a large retrospective review reporting no significant differences in surgical site infection rates between OABP + MBP and OABP alone,¹⁶ there is no strong evidence yet for the use of OABP without MBP. Further prospective randomised research is required to assess the benefits OABP in this setting.

The secondary outcomes of our study demonstrated a reduced length of hospital stay by 2.46 days on the introduction of OABP. This was clinically to be anticipated with a reduced rate of surgical site infection. Evidence in the literature also suggests a reduction in anastomotic leak rates and mortality. While we also demonstrated a reduction, we were unable to show statistical significance because of the size of our sample. A 2018 international prospective multicentre audit of 3676 patients concluded that there was an overall reduced rate of anastomotic leak from left-sided resections with combined MBP + OABP in comparison with MBP alone or no bowel preparation (6.1%, 9.2% and 8.7%, respectively).¹⁸

Our subgroup analysis demonstrated a significantly reduced incidence of surgical site infection in patients undergoing laparoscopic surgery. There were similar numbers of both right- and left-sided resections in both groups. In theory, laparoscopic surgical cases are expected to have lower frequencies of infectious complications due to smaller incision sites, less tissue trauma and manipulation of the tissues.¹¹ A wound protector was used to extract the specimen in all cases as routine practice. Although it has been difficult to account for this observation, other studies have shown similar outcomes with reduced surgical site infection incidence in laparoscopic colorectal surgery.¹¹

The use of OABP offers a prophylactic preventative solution when a surgical incision naturally disrupts the superficial abdominal wall layers and creates an environment susceptible to infection. Oral antibiotic prophylaxis provides additional benefits over intravenous antibiotics due to a cumulative direct suppression of the microbial colonic flora for hours after levels in the systemic circulation are undetectable.^{19,20}

This study must be interpreted within its limitations; it is a non-randomised interventional study with historical controls from a single centre. There were no standardised measures taken for patient care postoperatively, but all patients were on the enhanced recovery programme. Consecutive patients before and after protocol intervention were used in the study reducing any risk of selection bias, and this is supported by our analysis, demonstrating comparable patient baseline demographics and characteristics across both cohorts. The potential for bias was considered relatively low, taking into account consistent surgical

practices and techniques among the operating consultant surgeons. Although the team of surgical registrars changed, there was always a consultant presence. All other factors were considered consistent during the study period across both cohorts, including the choice of antibiotics, decided as a department before establishing the protocol. Therefore, the homogeneity of our study was considered strong.

Conclusion

There is robust evidence suggesting remarkable benefits of OABP for patients undergoing elective colorectal resection. The current evidence is largely from the United States where the use of OABP is routine practice in elective colorectal surgery. This prospective study and quality improvement intervention demonstrates a significantly reduced rate of overall surgical site infections in elective colorectal resections for benign and malignant pathologies in the practical setting of a standard colorectal department. The tangible benefits are two-fold: clinically with better patient experience and organisationally with a reduced hospital length of hospital stay. The use of MBP + OABP is shown to have improved patient outcomes and is a cost-effective intervention for the NHS. We would suggest incorporating the use of OABP combined with MBP within the current UK guidelines to mirror the overall beneficial effects described with the current evidence base to improve patient outcomes across the country.

Acknowledgements

We would like to thank the Digestive Disorders Foundation, Suffolk, for funding the statistical analysis for this work.

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