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Dual antibiotic prevention bundle is associated with decreased surgical site infections

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Abstract

Background—Gynecologic oncology surgery is associated with a wide variation in surgical site infection risk. The optimal method for infection prevention in this heterogeneous population remains uncertain.

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Study Design—A retrospective cohort study was performed to compare surgical site infection rates for patients undergoing hysterectomy over a 1-year period surrounding the implementation of an institutional infection prevention bundle. The bundle comprised pre-operative, intra-operative, and post-operative interventions including a dual-agent antibiotic surgical prophylaxis with cefazolin and metronidazole. Cohorts consisted of patients undergoing surgery during the 6 months prior to this intervention (pre-bundle) versus those undergoing surgery during the 6 months following the intervention (post-bundle). Secondary outcomes included length of stay, readmission rates, compliance measures, and infection microbiology. Data were compared with pre-specified one-sided exact test, Chi-square test, Fisher's exact test, or Kruskal-Wallis test as appropriate.

Results—A total of 358 patients were included (178 PRE, 180 POST). Median age was 58 (range 23–90) years. The post-bundle cohort had a 58% reduction in surgical site infection rate, 3.3% POST vs 7.9% PRE (−4.5%, 95% CI −9.3% to −0.2%, p=0.049) as well as reductions in organ space infection, 0.6% POST vs 4.5% PRE (−3.9%, 95% CI −7.2% to −0.7%, p=0.019), and readmission rates, 2.2% POST vs 6.7% PRE (−4.5%, 95% CI −8.7% to −0.2%, p=0.04). Gram-positive, Gram-negative, and anaerobic bacteria were all prevalent in surgical site infection cultures. There were no monomicrobial infections in post-cohort cultures (0% POST vs 58% PRE, p=0.04). No infections contained methicillin-resistant *Staphylococcus aureus*.

Conclusion—Implementation of a dual antibiotic infection prevention bundle was associated with a 58% reduction in surgical site infection rate after hysterectomy in a surgically diverse gynecologic oncology practice.

INTRODUCTION

Surgical site infection has been associated with a 3% mortality rate, extended hospital stay, increased rate of readmission, and long-term disability.[1–5] Initiatives aimed at infection reduction have been set forth by major organizations such as the Center for Medicare and Medicaid Services and the American College of Surgeons.[126] The resulting uptake of bundled surgical site infection prevention measures has successfully decreased infection rates across multiple surgical specialties.

Bundled interventions adapted by gynecologic oncology have yielded promising results among cancer patients undergoing bowel resections or debulking surgeries.[7–11] For these patients, surgical site infection can result in delays or even preclusion of life-saving chemotherapy, adding to the urgency of infection prevention.[12] The standard surgical practice of a gynecologic oncologist also encompasses benign gynecologic pathology and minimally invasive surgery. The effectiveness of a universally applied surgical site infection prevention bundle in this heterogeneous population, including standardized dual-agent antibiotic prophylaxis, has yet to be established.

A dual antibiotic surgical site infection prevention bundle was implemented for all gynecologic oncology patients undergoing hysterectomy at our institution. Herein we present a retrospective evaluation aimed at determining infection rates before and after this intervention.

METHODS

An institutional gynecologic oncology surgical site infection prevention bundle is summarized in Table 1.[17–101314] The study institution is a National Cancer Institute designated cancer center with an academic gynecologic oncology service serving patients from varied socioeconomic backgrounds. All bundle elements were implemented simultaneously on July 19, 2016 with Table 1 denoting the pre-bundle implementation status of each component. Of note, cohorts shared the same peri-operative warming practices as these were previously confirmed to be effective. There was no bundle component pertaining to bowel preparation and therefore these data were not collected; however, it is noted that there were no large practice changes to bowel preparation use patterns during the study period.

Following bundle implementation, a retrospective cohort study was performed aimed at determining surgical site infection rates for consecutive hysterectomy patients before and after implementation. Patients undergoing hysterectomy for any indication, benign or malignant, by the gynecologic oncology service from January 2016 through January 2017 were identified through surgical scheduling records and included in this study. The pre-bundle cohort includes all patients undergoing surgery during the 6 months prior to intervention and the post-bundle cohort includes those undergoing surgery during the 6 months following intervention.

The primary outcome was surgical site infection, as defined by the Center for Disease Control and Prevention National Healthcare Safety Network criteria. Wound culture collection technique was not standardized in this study. Secondary outcomes included length of stay, intensive care unit admission rate, 30-day readmission rate, additional procedures performed in the 30-day post-operative period (defined as wound opening and/or debridement, intra-abdominal drain placement, and reoperation), and microbiology patterns of infection.

After institutional review board approval (MCC #19 104 USF IRB #Pro 00030016), data pertaining to medical history, surgical variables, and post-operative outcomes including culture results were collected from the electronic medical records. Requirement for written informed consent was waived by the institutional review board given the nature of the project. The 30-day follow-up was not affected by the intervention and routinely included post-operative visits at 2 weeks and at 4–6 weeks. Prior to excluding surgical site infection, all clinical documentation and medication records were thoroughly reviewed to verify a patient was not treated for a surgical site infection. Patients without at least 30 days of post-operative follow-up were excluded, unless the lack of follow-up was related to patient death.

As a measure of bundle compliance, data for adherence to antibiotic protocols was collected for both cohorts by review of anesthesia medication administration records. Prior to bundle implementation, single-agent cefazolin was generally used with dosing of 1 g intravenouss (IV) if <80 kg or 2 g IV if ≥80 kg. Beta-lactam allergies were poorly investigated, and even with minor allergies an alternative combination of aztreonam 2 g IV and clindamycin (600 mg IV <80 kg or 900 mg IV ≥80 kg) was administered. To improve practices, the bundled

intervention included standard antibiotic order sets which involved combination surgical prophylaxis of cefazolin and metronidazole for all hysterectomy patients with re-dosing settings per the Infection Disease Society of America published guidelines.[15] New dosing practices included 2 g cefazolin (3 g if ≥120 kg) re-dosed every 4 hours and metronidazole 500 mg × 1. In addition, anesthesia and surgical teams received education regarding proper evaluation of penicillin allergies wherein cefazolin was only contra-indicated with history of beta-lactam-associated anaphylactic shock, angioedema, or bronchoconstriction. In the case of severe beta-lactam allergy, a combination of clindamycin 900 mg × 1 and gentamicin 5 mg/kg × 1 was administered.

Methicillin-resistant *Staphylococcus aureus* screening and decolonization data were also used at a measure of bundle compliance. Patients with a positive screen by polymerase chain reaction (PCR) nasal swab underwent decolonization protocol consisting of mupirocin 2% ointment to nares for 5 days, chlorhexidine gluconate shower for 5 days, and IV vancomycin 1 g (1.5 g if ≥80 kg) was added to surgical antibiotic prophylaxis.

Cohorts were compared for incidence of surgical site infection using a pre-specified one-sided exact test. Based on historical and published data, we have reason to believe that the rate before implementation was approximately 6% infection. Power is assessed at a significance level of 0.025 (estimating with a Bonferroni correction) to detect a 50% decrease in infection rate with a power = 0.81. All other demographic, clinical, and microbiologic data were compared using either a Chi-square test or Fisher's exact test for categorical variables and the Kruskal–Wallis test for numeric variables. Non-parametric tests were used and were deemed significant at an alpha = 0.05. Analyses were performed in SAS v. 9.4 (SAS Institute, Cary, NC, USA).

RESULTS

A total of 358 patients were included (178 PRE, 180 POST). Most patients identified their race as Caucasian (82.7%), followed by Black (8.9%), Asian (3.5%), and Hispanic (1.4%). Cohorts were comparable for baseline clinical variables except for rates of para-aortic lymphadenectomy, which was more frequent in the pre-bundle cohort, and use of topical hemostatic agents intra-operatively, which was more frequent post-bundle (Table 2). There were ~11% more minimally invasive hysterectomies (robotic + laparoscopic) in the post-bundle cohort (63.9% POST vs 52.8% PRE, p=0.035).

Indication for hysterectomy included ovarian cancer (33 POST, 41 PRE), uterine cancer (70 POST, 73 PRE), cervical cancer (6 POST, 10 PRE), benign ovarian mass (26 POST, 24 PRE), benign uterine pathology (9 POST, 12 PRE), precancerous lesion of the uterus or cervix (22 POST, 12 PRE), genetic predisposition to cancer (8 POST, 5 PRE), non-gynecologic malignancy (5 POST, 1 PRE), and other benign lesion not listed (1 POST, 0 PRE).

Outcomes after bundle implementation are summarized in Table 3. We found an associated decreased incidence of surgical site infection in the post-bundle cohort, 3.3% POST vs 7.9% PRE (−4.6%, 95% CI −9.3% to −0.2%, p=0.049). Specifically, there was a reduction in

organ space infection after bundle implementation, 0.6% POST vs 4.5% PRE (−3.9%, 95% CI −7.2% to −0.7%, p=0.019). Of note, one patient in the pre-cohort developed both a superficial wound infection as well as an organ space infection. For patients undergoing laparoscopic surgery, 3/94 (3.2%) pre-cohort patients developed surgical site infection compared with 0/115 (0%) post-cohort patients. Two of the three laparoscopic surgical site infection were categorized as organ space infection.

The 30-day all-cause readmission after surgery was lower in the post-bundle group, 2.2% POST vs 6.7% PRE (−4.5%, 95% CI −8.7% to −0.2%, p=0.043). There was a trend towards decreased mean length of stay and need for intensive care unit admission in the post-bundle group; however, this did not reach statistical significance (Table 3). There were no safety issues identified with 4% chlorhexidine gluconate vaginal preparation.

As a measure of bundle component compliance, we found that a multi-agent regimen was used more often in the post-bundle cohort (162/180 (90%) POST vs 23/178 (12.9%) PRE, p=0.0001). Most pre-bundle patients who received combination antibiotic prophylaxis received it because of penicillin allergy. There was no meaningful difference in the number of penicillin-allergic patients between cohorts (n=19 POST, n=21 PRE). Pre-bundle penicillin-allergic patients most commonly received combination clindamycin and aztreonam (n=20) followed by clindamycin and gentamicin (n=1). Post-bundle patients with severe penicillin allergy most commonly received combination clindamycin and gentamicin per protocol (n=13) followed by clindamycin and aztreonam (n=4) or clindamycin alone (n=2).

Methicillin-resistant *S. aureus* screening compliance was increased after bundle intervention (159/180 (88.3%) POST vs 129/178 (72.5%) PRE, p<0.001). There was no difference in positive screens (6/159 (3.8%) POST vs 4/129 (3.1%) PRE, p=1.0) but for those who screened positive there was increased adherence to the decolonization protocol (5/6 (83%) POST vs 2/4 (50%) PRE, p=0.91). None of the cultures involved methicillin-resistant *S.aureus*.

A total of 20/358 (5.6%) patients included in this study developed surgical site infection. Culture results were available for 17/20 patients. Cultures from the pre-bundle cohort had a higher rate of one single bacterial type identified, ie, monomicrobial infections (7/12 (58%) PRE vs 0/5 (0%) POST, p=0.04). A total of 20 distinct pathogens were identified in the 17 surgical site infection cultures, summarized in Table 4, arranged in order of frequency. Gram-positive bacteria were present in 9/14 (64.3%) pre-bundle cultures and 5/6 (83.3%) post-bundle cultures (p=0.61). Gram-negative bacteria were present in 7/14 (50%) pre-bundle cultures and 2/6 (33.3%) post-bundle cultures (p=0.64). Anaerobic bacteria were present in 7/14 (50%) pre-bundle and 4/6 (66.7%) post-bundle cultures (p=0.64).

DISCUSSION

Surgical site infection is the most common hospital-acquired infection and is recurrently associated with negative outcomes relating to patient safety and costs of care. In an attempt to prevent this outcome in our gynecologic oncology hysterectomy population a surgical site

infection prevention bundle was implemented. This bundle, including dual-agent surgical prophylaxis with cefazolin and metronidazole as well as chlorhexidine gluconate vaginal preparation, was associated with a 58% reduction in surgical site infection following hysterectomy. Specifically, we found a lower rate of organ space infection as well as a significant reduction in 30-day readmission rates.

Surgical site infection bundles have been adopted into gynecologic oncology in recent years mainly due to the proven success in the colorectal literature.[11] In 2016, Johnson et al published an initial report on surgical site infection prevention bundles in gynecologic oncology which was associated with decreased infection rates for ovarian and uterine cancer patients undergoing laparotomy.[78] Following this, Schiavone et al reported infection reduction after bundled intervention in gynecologic cancer patients undergoing colon resection.[10] A similar report by Lippitt et al described a five-point bundle resulting in reduced surgical site infections in ovarian cancer patients undergoing cytoreductive surgery.[9] All three of these studies include patients undergoing extensive open procedures at high risk for infection.

Surgical site infection prevention bundles may also be effective in those at lower risk of infection including minimally invasive surgery patients. Nguyen et al reported an infection reduction from 12.1% to 5.4% with bundle use in patients with gynecologic malignancy undergoing open or laparoscopic surgery.[16] Additionally, Andiman et al described lower rates of surgical site infection following open or laparoscopic hysterectomy with a seven-point bundle in a large group setting of gynecologists and gynecologic subspecialists.[17] These studies suggest a benefit to bundled interventions in both high- and low-risk patients. However, outcome data are lacking for a single population encompassing all of the diverse characteristics found in a standard gynecologic oncology practice including benign and malignant pathology, as well as open and laparoscopic technique, while remaining specific for surgery having been completed by a gynecologic oncologist. In evaluating such outcomes in this broad yet specific population, the current study suggests efficacy of our institutional surgical site infection prevention bundle when used routinely for all comers undergoing hysterectomy by a gynecologic oncologist.

A unique component of this bundle is the use of dual antibiotic prophylaxis with cefazolin and metronidazole. Current practices support the use of single-agent surgical prophylaxis, most often incorporating a second-generation cephalosporin.[68–1018] The addition of metronidazole addresses a common problem of bacterial vaginosis which can affect up to one in three women.[19] Post-hysterectomy surgical site infection in the presence of bacterial vaginosis can be as high as 34%, with randomized data showing that pre-operative metronidazole significantly lowers the rate of vaginal cuff infection in these patients.[20] Given the decreased infection rate seen in the present study, it may be reasonable to add metronidazole routinely for patients undergoing hysterectomy. Additionally, as we demonstrated, surgical site infections were frequently polymicrobial, therefore using broad-spectrum antibiotic coverage may be more appropriate.

A history of methicillin-resistant *S. aureus* infection has been associated with increased risk of organ space infection in patients with endometrial cancer.[21] However, it remains unclear

if decontamination for carriers actually prevents infection. A Cochrane database review was unable to determine benefit of methicillin-resistant *S. aureus* screening in the prevention of surgical site infection and reported very limited randomized control trial evidence for the effectiveness of nasal decontamination for infection prevention.[21] In the current study, we did not identify any surgical site infection related to methicillin-resistant *S. aureus*. The clinical and cost effectiveness of methicillin-resistant *S. aureus* interventions in gynecologic oncology should be further investigated.

The use of 4% chlorhexidine gluconate vaginal preparation, in lieu of traditional iodine preparation, was a notable change in our institutional practice. Evidence shows povidone-iodine is most effective after several minutes of drying, and povidone iodine within the vaginal rugae may not dry appropriately thereby decreasing its antimicrobial effectiveness.[22] This differs from alcohol-based solution containing chlorhexidine gluconate which dries more rapidly and may result in decreased vaginal bacterial counts compared with povidone-iodine.[2324] The American College of Obstetricians and Gynecologists supports vaginal preparation with chlorhexidine gluconate solutions of low alcohol concentration (4%).[13] Interestingly, in this report, the decreased surgical site infection rate after bundled intervention was largely due to decline in pelvic and vaginal cuff abscesses. This finding could also be attributed to a decrease in vaginal bacterial load from chlorhexidine gluconate vaginal preparation. Further studies are warranted to discern if the 4% chlorhexidine gluconate preparation or dual-antimicrobial prophylaxis conferred the greatest impact on infection rates.

The low overall infection rate in this study limits our ability to evaluate additional surgical factors associated with surgical site infection in this population. The non-blinded nature of the study also allows for the introduction of bias. For example, in the setting of risk reduction attempts, surgeons may have made changes in practice or altered surgical technique, as evidenced by the increase in use of hemostatic agents and increase in laparoscopic approach. These changes may have significantly contributed to the observed outcome. We do note, however, that while there were more laparoscopic cases in the post-bundle cohort as a whole, when only considering the laparoscopic cases from PRE and POST groups, there were fewer infections associated with laparoscopy on the POST cohort. This suggests that the infection prevention bundle was still contributory to infection prevention. We also note that data regarding patterns of intravenous fluid management and bowel preparation were not collected as these practices are not affected directly by bundle intervention. However, these are important factors to consider in association with peri-operative complications. Additionally, the nature of a bundled intervention precludes analysis of the most beneficial components. Cost-benefit analysis was not within the scope of the current study but we note that recent data suggest peri-operative costs are unchanged with the use of enhanced recovery after surgery protocols.[25] The present study was completed in a pre-enhanced recovery protocol population; therefore, future cost effectiveness studies on combined enhanced recovery protocols and surgical site infection prevention bundles would be informative.

Despite the above limitations, we believe this study represents the effects associated with a large-scale surgical site infection prevention bundle in a heterogeneous population

undergoing hysterectomy. This study is strengthened by simultaneous implementation of all bundle components allowing a true evaluation of associated bundle effect as a whole. We have also highlighted important concepts for further prospective investigation including combination cefazolin and metronidazole surgical prophylaxis and routine chlorhexidine gluconate 4% alcohol vaginal preparation.

CONCLUSIONS

We present data showing an associated 58% reduction in surgical site infection following hysterectomy in a surgically diverse gynecologic oncology population undergoing hysterectomy after implementation of a dual antibiotic infection prevention bundle. A broad group of pathogens were identified in infections after hysterectomy, supporting the use of multi-agent surgical antibiotic prophylaxis. With continued reports of bundled intervention outcomes specific to gynecologic surgery, the most effective components may be identified via future analysis. Future cost analyses would contribute to our further understanding of the impact of surgical site infection reduction on patient care.

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HIGHLIGHTS

- A 58% reduction in surgical site infection after hysterectomy was found after introduction of cefazolin and metronidazole prophylaxis.
- The dual-agent surgical site infection bundle cohort had a significantly lower readmission rate compared to the pre-bundle cohort.
- Surgical site infection after hysterectomy is multi-microbial and likely benefits from dual antibiotic prophylaxis.

Table 1

Gynecologic oncology surgical site infection prevention bundle

Bundle components	**Prior compliance***
Pre-operative	
MRSA screening by PCR nasal swab and decolonization protocol if positive	Inconsistent
Supplement patient education with CDC guide	None
4% CHG shower the night before and morning of surgery	Inconsistent
2% CHG wipes in pre-op completed by a member of the surgical team	None
Intra-operative	
Dual-antibiotic surgical prophylaxis - cefazolin and metronidazole IV	Rarely
Standardized redosing of antibiotic surgical prophylaxis	Inconsistent
Pre-operative antibiotic order sets standardized for all hysterectomies	None
Complete coverage of incisional area with 2% CHG and 70% isopropyl alcohol	Consistent
Vaginal preparation with 4% CHG	None
Instruments for closing fascia and skin kept covered on back table	None
Staff glove change before fascial closure with gown change if soiled	Rarely
Post-operative	
Practice standard hand hygiene	Consistent
Hand-cleansing agent readily available	Inconsistent
Ensure dressing removal within 24 hours	Rarely
Patient shower with 4% CHG after dressing removal (POD#1)	None
Patient education on wound care and infection symptoms	Inconsistent
Glucose control with blood glucose goal <180 mg/dL	Inconsistent
Discharge patient with 4 oz bottle of 4% CHG shower on day after discharge	None

* Describes practice patterns prior to bundle implementation.

CDC, Centers for Disease Control and Prevention; CHG, chlorhexidine gluconate; IV, intravenous; MRSA, methicillin-resistant *Staphylococcus aureus*; oz, ounce; PCR, polymerase chain reaction; POD, post-operative day.

Table 2

Patient characteristics

Characteristic	PRE (n=178)	POST (n=180)	(Difference) 95% CI	P value
Age (years)	57.2 (13.1)	57.1 (12.3)	(−0.23) to 2.89 to 2.41	0.910
BMI (kg/m^2)	31.6 (8.3)	31.1 (8.4)	(−0.56) to 2.31 to 1.19	0.454
Hypertension	71 (40.1)	79 (43.9)	(4.00) to 6.21 to 14.21	0.520
Diabetes	23 (12.9)	29 (16.1)	(3.19) to 4.10 to 10.48	0.454
Smoking status			(6.57) to 0.19 to 13.3	0.155
Never smoker	115 (64.6)	105 (58.3)		
Former smoker	47 (26.4)	47 (26.1)		
Current smoker	16 (9.0)	28 (15.6)		
Mental health diagnosis	32 (17.9)	24 (13.3)	(−4.64) to 12.16 to 3.87	0.247
Prior abdominal surgery	106 (59.6)	112 (62.2)	(2.67) to 7.44 to 12.78	0.588
Malignant disease	125 (69.8)	113 (62.8)	(7.45) to 2.50 to 17.61	0.147
History of pelvic radiation	4 (2.3)	9 (5)	(2.77) to 1.09 to 6.62	0.258
Neoadjuvant chemotherapy	24 (13.5)	17 (9.4)	(−3.96) to 10.53 to 2.61	0.249
Mode of hysterectomy			(−10.82) to 20.95 to −0.68	0.194
Total laparoscopic hysterectomy	67 (37.6)	73 (40.6)		
Robotic hysterectomy	27 (15.2)	42 (23.3)		
Total abdominal hysterectomy	84 (47.2)	65 (36.1)		
Radical hysterectomy	12 (6.7)	9 (5)	(−1.70) to 6.56 to 3.15	0.509
Pelvic LND	72 (40.5)	64 (35.6)	(−5.67) to 14.69 to 5.36	0.384
Para-aortic LND	34 (19.1)	18 (10)	(−8.99) to 16.22 to −1.77	0.016
Appendectomy	9 (5.1)	5 (2.8)	(−2.25) to 6.25 to 1.75	0.290
Bowel resection	8 (4.5)	15 (8.3)	(3.86) to 1.18 to 8.91	0.195
Estimated blood loss (mL)	236 (284.3)	222.78 (320.8)	(−12.31) to 75.21 to 50.60	0.043
Total surgical time (min)	194.1 (72.5)	198.3 (77.2)	(4.50) to 11.08 to 20.08	0.854
Individuals scrubbed	5 (4–6)	5 (4–6)	(0.29) to 0.012 to 0.59	0.132
Individuals in room	10 (9–12)	10 (9–12)	(0.31) to 0.24 to 0.87	0.204
Hemostatic agent use	43 (24.2)	84 (46.7)	(22.64) 13.04 to 32.25	<0.001
Lowest intra-op temperature	35.2 (1.1)	35.3 (0.9)	(0.03) to 0.18 to 0.24	0.779

Characteristic	PRE (n=178)	POST (n=180)	(Difference) 95% CI	P value
Temp on PACU arrival	36.5 (0.3)	36.6 (0.4)	(0.04) to 0.04 to 0.11	0.593
Fasting blood glucose POD#1	129.5 (35.7)	130.1 (38.6)	(1.08) to 6.66 to 8.81	0.928

Data are presented as mean (SD) or median (IQR) as appropriate. Temperature is reported as degrees Celsius. Difference and confidence intervals are presented as difference in mean for continuous variables and difference in percent risk for categorical variables.

BMI, body mass index; CI, confidence interval; intra-op, intra-operatively; LND, lymphadenectomy; min, minute; PACU, post-anesthesia care unit; POD, post-operative day; POST, post-intervention cohort; PRE, pre-intervention cohort; Temp, temperature in degrees Celsius.

Table 3

Outcomes after bundled intervention

Outcome	PRE (n=178)	POST (n=180)	(Difference) 95% CI	P value
Surgical site infection	14 (7.9)	6 (3.3)	(−4.53) to 9.28 to 0.21	0.0499
Superficial infection	6 (3.4)	4 (2.2)	(−1.15) to 4.56 to 2.27	0.541
Deep infection	1 (0.6)	1 (0.6)	(−0.01) to 1.55 to 1.54	1
Organ space infection	8 (4.5)	1 (0.6)	(−3.94) to 7.17 to −0.71	0.019
ICU admission	4 (2.2)	0 (0)	(−1.12) to 2.66 to 0.42	0.059
Return to the OR	2 (1.1)	1 (0.5)	(−0.56) to 2.45 to 1.32	0.622
Readmission <30 days	12 (6.7)	4 (2.2)	(−4.48) to 8.73 o −0.23	0.043
Procedure preformed	9 (5.1)	6 (3.3)	(−1.69) to 5.83 to 2.44	0.443
Length of stay	3.2 (3.0)	2.7 (2.4)	(−0.56) to 1.13 to 0.01	0.053

Data are presented as n (%) or mean (standard deviation) as appropriate.

Difference and confidence intervals are presented as difference in mean for continuous variables and difference in percent risk for categorical variables.

CI, confidence interval; ICU, intensive care unit; OR, operating room; POST, post-intervention cohort; PRE, pre-intervention cohort.

Table 4

Microbiology of surgical site infections after hysterectomy

Pathogen	G+	G−	An	PRE	POST	Total
Enterococcus faecalis	x			3	1	4
Enterococcus faecium	x			0	1	1
Streptococcus agalactiae	x		x	1	1	2
Streptococcus viridans	x			0		2
Peptostreptococcus magnus	x		x	0	1	1
Methicillin-sensitive *Staphylococcus aureus*	x			2	1	3
Coagulase-negative *Staphylococcus*	x			2	1	3
Eggerthella lenta	x		x	2		2
Diptheroid	x			0	1	1
Propionibacerium granulosum	x		x	0	1	1
Mixed Gram-positive	x			1	0	1
Bacteroides fragilis		x	x	3	0	3
Bacteroides vulgatus		x	x	1	0	1
Bacteroides thetaiotaomicron		x	x	0	1	1
Pseudomonas aeruginosa		x		2	0	2
Escherichia coli		x	x	1	1	2
Proteus mirabilis		x	x	1	0	1
Enterobacter cloacae		x	x	0	1	1
Mixed anaerobic			x	1	1	2
Candida galbrata				1	0	1

An, anaerobic bacteria; G+, Gram-positive bacteria; G−, Gram-negative bacteria; POST, post-bundle group; PRE, pre-bundle group.