Postoperative Prophylactic Antibiotics in Spine Surgery

A Propensity-Matched Analysis

Matthew V. Abola, MD, Charles C. Lin, MD, MS, Lawrence J. Lin, BA, William Schreiber-Stainthorp, BS, Anthony Frempong-Boadu, MD, Aaron J. Buckland, MD, and Themistocles S. Protopsaltis, MD

Investigation performed at NYU Langone Health, New York, NY

Background: Surgical site infections are common and costly complications after spine surgery. Prophylactic antibiotics are the standard of care; however, the appropriate duration of antibiotics has yet to be adequately addressed. We sought to determine whether the duration of antibiotic administration (preoperatively only versus preoperatively and for 24 hours postoperatively) impacts postoperative infection rates.

Methods: All patients undergoing inpatient spinal procedures at a single institution from 2011 to 2018 were evaluated for inclusion. A minimum of 1 year of follow-up was used to adequately capture postoperative infections. The 1:1 nearest-neighbor propensity score matching technique was used between patients who did and did not receive postoperative antibiotics, and multivariable logistic regression analysis was conducted to control for confounding.

Results: A total of 4,454 patients were evaluated and, of those, 2,672 (60%) received 24 hours of postoperative antibiotics and 1,782 (40%) received no postoperative antibiotics. After propensity-matched analysis, there was no difference between patients who received postoperative antibiotics and those who did not in terms of the infection rate (1.8% compared with 1.5%). No significant decrease in the odds of postoperative infection was noted in association with the use of postoperative antibiotics (odds ratio = 1.17; 95% confidence interval, 0.620 to 2.23; p = 0.628). Additionally, there was no observed increase in the risk of *Clostridium difficile* infection or in the short-term rate of infection with multidrug-resistant organisms.

Conclusions: There was no difference in the rate of surgical site infections between patients who received 24 hours of postoperative antibiotics and those who did not. Additionally, we found no observable risks, such as more antibiotic-resistant infections and *C. difficile* infections, with prolonged antibiotic use.

Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Surgical site infections (SSIs) following spine surgery are common, preventable, and costly complications. Reported rates of deep infection following spine surgery have been reported to range from approximately 1% to 2%, with variability observed between studies involving different patient populations, surgical procedures, and sample sizes[1-6]. The Spine Patient Outcomes Research Trial (SPORT) demonstrated postoperative infection rates of 2% to 4% for lumbar disc herniation, spinal stenosis, and degenerative spondylolisthesis[2-4]. Similar rates of infection (1.1% to 1.9%) have been observed in Medicare data for cervical and lumbar spine procedures[5,7]. Even with variable rates of infection after surgery, SSIs remain the most common complication after spine surgery. To minimize the rate of postoperative infections, a compendium of research and guidelines has been dedicated to their prevention.

In 2003, the American College of Surgeons, in conjunction with the Centers for Disease Control and Prevention (CDC), Centers for Medicare & Medicaid Services (CMS), and other professional organizations, developed the Surgical Care Improvement Project (SCIP), which established the metrics by which SSI prevention is tracked[8-10]. These metrics include (1) the proportion of patients who receive antimicrobial prophylaxis within 1 hour prior to incision, (2) the proportion of patients who receive a prophylactic agent within currently

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published guidelines, and (3) the proportion of patients whose antimicrobial prophylaxis is discontinued within 24 hours after the end of surgery[8-10]. Growing evidence, however, indicates that 24 hours of postoperative antibiotics may pose additional risks, such as antibiotic resistance, without added prevention benefit in patients undergoing orthopaedic procedures[11-15].

Several studies in the spine literature have evaluated the duration and effectiveness of prophylactic antibiotics; however, several questions have yet to be adequately addressed. First, does the duration of antibiotic administration (preoperatively only versus preoperatively and for 24 hours postoperatively) impact postoperative infection rates? Second, is prolonged antibiotic use associated with any observable risks, such as more antibiotic-resistant infections and *Clostridium difficile* infections? To answer these questions, we conducted a retrospective, propensity-matched analysis of all inpatient spine procedures at a single tertiary academic institution.

Materials and Methods

Patient Selection and Data Collection

A retrospective review of all primary spinal procedures that were performed at a single institution from 2011 to 2018 for the treatment of degenerative conditions and scoliosis in patients ≥18 years of age, with minimum 1-year follow-up, was performed. We excluded all outpatient procedures, oncological procedures, procedures for the treatment of spine infections, and revision procedures. The patients were stratified into 2 groups: (1) those who had received preoperative antibiotics and 24 hours of postoperative antibiotics and (2) those who had received preoperative antibiotics with appropriate intraoperative redosing and no postoperative antibiotics. Postoperative antibiotics were assigned on the basis of surgeon preference.

Standardized Prophylactic Antibiotic Regimens

Patients received prophylactic cefazolin, or, if a severe allergy was documented in the chart and confirmed by patient report, vancomycin or clindamycin. Prophylactic gentamycin was additionally administered to patients undergoing lumbar surgery. Follow-up data in the chart were reviewed until a minimum of 1 year of follow-up. Culture-related data, including organism types and sensitivities from available wound cultures, were also collected.

Outcome Variables

The primary end point of the present study was deep SSI, defined as any infection after the index procedure requiring irrigation and debridement and possible removal of implants. Secondary end points included the prevalence of antibiotic-resistant organisms, gauged from wound cultures and sensitivity data, and comparison of *C. difficile* infection rates between the 2 groups. Other variables such as age, American Society of Anesthesiologists (ASA) class, body mass index (BMI), comorbidity burden, and smoking were also collected. The Charlson Comorbidity Index (CCI) was calculated from the comorbidity data. Procedural data, including estimated blood loss, operative time, instrumentation, levels of fusion, type of approach (anterior, posterior, or combined), complex plastic surgery closure, drain placement, type of procedure (minimally invasive or open), and level of the procedure (cervical, thoracic, or lumbar) were collected.

Statistical Analysis

Univariate analyses were performed with the Fisher exact test for categorical variables and with the t test for continuous variables to assess differences in demographic characteristics between patients who received 24 hours of postoperative antibiotics and those who did not. Multivariate regression was performed to assess whether the administration of postoperative antibiotics was an independent risk factor for infection when controlling for age, sex, BMI, smoking, CCI, estimated blood loss, operative time, levels of fusion, complex plastic surgery closure, approach (anterior, posterior or combined), type of procedure (minimally invasive versus open), and level of involvement (cervical, thoracic or lumbar).

To adequately control for confounding variables that impact infection rates, we performed propensity score matching using 1:1 matching to nearest neighbors between patients who did and did not receive postoperative antibiotics[16]. Propensity-matched variables were selected on an a priori basis and included age, sex, BMI, ASA score, smoking, CCI, levels fused, operative time, estimated blood loss, complex plastic surgery closure, approach (anterior, posterior or combined), type of procedure (minimally invasive versus open), and level of involvement (cervical, thoracic or lumbar). Because we included scoliosis cases, adding the number of levels fused was important to adequately match these cases and their postoperative antibiotic regimen. Balance after matching was assessed with use of standardized mean differences with a threshold of <0.1. After balancing, 1,162 patients remained in each group, for a total of 2,324 patients. Further assessment of balance was conducted with use of univariate analyses on baseline demographic data. Both the Fisher exact test and the McNemar test were used to compare the infection rates after propensity score matching, and bivariate regression was then performed to assess the odds ratio (OR) for postoperative infection associated with the use of postoperative antibiotics.

With use of an SSI difference of 1.4% based on previous studies of SSI rates, an alpha level of 0.05, and power of 0.80, the total projected sample size needed was approximately 2,054 (1,027 per arm)[17]. All statistical analysis was performed with use of R (version 3.6.2; R Foundation for Statistical Computing). The level of significance was set at $p < 0.05$. Institutional review board approval was obtained prior to initiation of the study.

Results

A total of 6,655 patients were evaluated for inclusion, and a total of 4,454 patients were included for analysis after inclusion and exclusion criteria were applied. In the unmatched cohort, 1,782 patients (40%) received no postoperative antibiotics and 2,672 patients (60%) received postoperative antibiotics. Demographic characteristics are shown in Table I. Patients

TABLE I Characteristics of Patients Managed with and without Postoperative Antibiotics*

	No Postop. Antibiotics (N = 1,782)	Postop. Antibiotics (N = 2,672)	Standardized Mean Difference	P Value
Age† *(yr)*	59.7 ± 14.3	58.1 ± 14.4	0.11	<0.001†
Male sex *(no. of patients)*	909 (51.0%)	1,372 (51.3%)	0.01	0.849
Smoking *(no. of patients)*	256 (14.4%)	451 (16.9%)	0.07	0.027†
BMI† *(kg/m²)*	29.1 ± 6.1	29.8 ± 6.2	0.12	<0.001†
BMI category *(no. of patients)*				<0.001†
Underweight	28 (1.6%)	38 (1.4%)		
Normal	427 (24.0%)	494 (18.5%)		
Overweight	612 (34.3%)	963 (36.0%)		
Class-1 obesity	440 (24.7%)	673 (25.2%)		
Class-2 obesity	184 (10.3%)	337 (12.6%)		
Class-3 obesity	91 (5.1%)	167 (6.3%)		
ASA score *(no. of patients)*				0.028†
1	553 (31.0%)	839 (31.4%)		
2	632 (35.5%)	1,030 (38.5%)		
3	567 (31.8%)	747 (28.0%)		
4	30 (1.7%)	56 (2.1%)		
CCI†	2.3 ± 1.8	2.0 ± 1.8	0.15	<0.001†
Diabetes mellitus *(no. of patients)*	233 (13.1%)	336 (12.6%)	0.02	0.657
COPD *(no. of patients)*	99 (5.6%)	138 (5.2%)	0.02	0.616
CHF *(no. of patients)*	15 (0.8%)	19 (0.7%)	0.02	0.753
CKD *(no. of patients)*	50 (2.8%)	41 (1.5%)	0.09	0.005†
IA *(no. of patients)*	78 (4.4%)	75 (2.8%)	0.08	0.006†
MIS *(no. of patients)*	178 (10.0%)	347 (13.0%)	0.09	0.003†
Instrumentation *(no. of patients)*	1,419 (79.6%)	2,261 (84.6%)	0.13	<0.001†
No. of levels fused†	2.7 ± 3.5	2.8 ± 3.8	0.03	0.330
Approach *(no. of patients)*				<0.001†
Anterior	369 (21.5%) of 1,720	459 (17.8%) of 2,579		
Posterior	1,181 (68.7%) of 1,720	1,741 (67.5%) of 2,579		
Combined	170 (9.9%) of 1,720	379 (14.7%) of 2,579		
EBL† *(mL)*	446.8 ± 782.24	590.6 ± 993.8	0.16	<0.001†
Operative time† *(min)*	237.4 ± 134.38	245.3 ± 132.1	0.06	0.055
Level of procedure *(no. of patients)*				
Cervical	515 (28.9%)	579 (21.7%)	0.17	<0.001†
Thoracic	216 (12.1%)	273 (10.2%)	0.06	0.050
Lumbar	1,188 (66.7%)	1,933 (72.3%)	0.12	<0.001†
Drain *(no. of patients)*	1,020 (57.2%)	1,628 (60.9%)	0.08	0.015†
Complex plastic surgery closure *(no. of patients)*	92 (5.2%)	77 (2.9%)	0.12	<0.001†

*CCI = Charlson Comorbidity Index, COPD = chronic obstructive pulmonary disease, CHF = congestive heart failure, CKD = chronic kidney disease, IA = inflammatory arthritis, MIS = minimally invasive surgery, and EBL = estimated blood loss. †The values are given as the mean and the standard deviation. ‡Significant.

in the postoperative antibiotics group were more likely to be male, to have a history of smoking, and to have a higher BMI. The postoperative antibiotics group also had a higher proportion of ASA class-3 and 4 patients and a greater mean CCI. In terms of specific comorbidities, the group that did not receive postoperative antibiotics had higher rates of diabetes, chronic

obstructive pulmonary disease, and congenital heart failure, but the differences were not significant. Additionally, the postoperative antibiotics cohort had a greater percentage of procedures involving instrumentation, more levels fused, greater estimated blood loss, and longer operative time. The rate of infection in the group that received postoperative antibiotics was not significantly different from that in the group that did not (1.6% compared with 1.6%; p = 0.99) (Fig. 1). The rate of infection with *C. difficile* was also not significantly different between the groups that did and did not receive postoperative antibiotics (0.04% compared with 0%; p = 0.99).

In multivariate logistic regression, male sex, increased BMI, and greater estimated blood loss were significant independent risk factors for postoperative infection. However, administration of postoperative antibiotics was not protective against infection (Table II).

After propensity-matched analysis, there were no significant differences in demographic characteristics between the 2 groups (Table III). The infection rate was 1.8% in the group that received postoperative antibiotics and 1.5% in the group that did not (Fisher exact test, p = 0.859; McNemar test, p = 0.748). No significant decrease in the odds of postoperative infection was noted in association with the use of postoperative antibiotics (OR = 1.17; 95% confidence interval [CI], 0.620 to 2.23; p = 0.628).

For culture data, there were no significant differences between the group that received postoperative antibiotics and the group that did not in terms of the prevalence of different types of organisms (Fig. 2). The most common organism isolated was *Staphylococcus aureus,* which comprised 47% of the cultures that yielded an organism. All 3 patients who were infected with methicillin-resistant *S. aureus* (MRSA) had received postoperative antibiotics.

TABLE II Regression Analysis Assessing Independent Variables Associated with Infection*

	OR (95% CI)	P Value
Postoperative antibiotics	0.896 (0.542, 1.506)	0.672
Age	0.983 (0.960, 1.008)	0.167
Male sex	1.913 (1.147, 3.279)	0.015†
BMI	1.074 (1.040, 1.107)	<0.001†
Smoking	1.745 (0.916, 3.157)	0.076
CCI	1.128 (0.919, 1.349)	0.219
Diabetes mellitus	1.784 (0.885, 3.486)	0.096
EBL‡	1.027 (1.003, 1.049)	0.018†
Operative time	0.999 (0.997, 1.002)	0.655
MIS	0.381 (0.086, 1.180)	0.135
No. of levels fused	1.008 (0.926, 1.073)	0.833
Anterior approach	0.136 (0.005, 3.728)	0.176
Posterior approach	2.312 (0.492, 41.300)	0.411
Combined approach	1.217 (0.184, 23.934)	0.861
Cervical	0.794 (0.259, 2.094)	0.661
Thoracic	0.876 (0.331, 2.065)	0.775
Lumbar	0.686 (0.384, 1.239)	0.206
Drain	1.425 (0.781, 2.755)	0.268
Complex plastics closure	0.970 (0.299, 2.624)	0.956

*OR = odds ratio, CI = confidence interval, BMI = body mass index, CCI = Charlson Comorbidity Index, EBL = estimated blood loss, and MIS = minimally invasive surgery. †Significant. ‡EBL was scaled by 100.

Discussion

Our propensity-matched analysis demonstrated no difference in SSI between patients who received postoperative antibiotics and those who did not (1.8% compared with 1.5%). Among those who received postoperative antibiotics, we detected no increase in resistant organisms from wound cultures and no increased rates of *C. difficile* infection. In the published literature, there is limited evidence to support postoperative antibiotic prophylaxis for patients undergoing spine surgery. Our study, with adequate sample size, statistical methodology, and follow-up, adds to this evidence and improves on the previous literature.

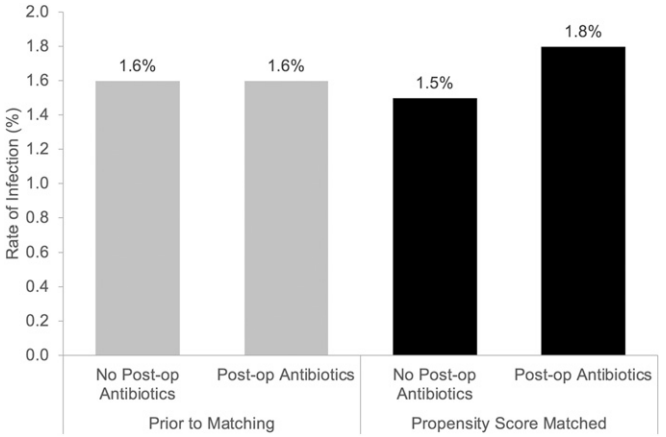

Fig. 1

Infection rates for the group that received no postoperative antibiotics and the group that received postoperative antibiotics, prior to matching and after propensity score matching.

In the spine literature to date, studies evaluating preoperative-only versus preoperative and postoperative antibiotics have shown no added benefit but have had limited generalizability due to underpowered sample sizes and heterogenous control and comparison groups[12,15,18,19]. Hellbusch et al. performed a randomized controlled trial of 269 patients undergoing instrumented lumbar fusion who received either a preoperative-only dose or an extended 10-day antibiotic protocol[18]. Patients who were randomized into the extended postoperative protocol received the standard preoperative and intraoperative prophylactic dosing as well as cefazolin for 3 days followed by oral cephalexin for 7 days. The infection rate was 4.3% in the preoperative-only cohort and 1.7% in the extended protocol cohort (p > 0.25). The trial was underpowered by approximately 1,100 patients to detect significant differences in infection rates. Additionally, the authors did not report adverse events associated

TABLE III Characteristics of Patients After Propensity Score Matching*

	No Postop. Antibiotics (N = 1,162)	Postop. Antibiotics (N = 1,162)	Standardized Mean Difference	P Value
Age† *(yr)*	58.9 ± 14.1	59.0 ± 14.0	0.00	0.976
Male sex *(no. of patients)*	577 (49.7%)	578 (49.7%)	0.00	1.000
Smoking *(no. of patients)*	193 (16.6%)	181 (15.6%)	0.03	0.535
BMI† *(kg/m²)*	29.6 ± 6.1	29.6 ± 5.7	0.01	0.848
ASA score†	2.0 ± 0.8	2.0 ± 0.8	0.00	0.960
CCI†	2.1 ± 1.7	2.1 ± 1.8	0.01	0.819
Diabetes mellitus *(no. of patients)*	145 (12.5%)	154 (13.3%)	0.02	0.620
COPD *(no. of patients)*	55 (4.7%)	60 (5.2%)	0.02	0.702
CHF *(no. of patients)*	5 (0.4%)	6 (0.5%)	0.01	1.000
CKD *(no. of patients)*	26 (2.2%)	15 (1.3%)	0.07	0.114
IA *(no. of patients)*	42 (3.6%)	39 (3.4%)	0.01	0.821
MIS *(no. of patients)*	145 (12.5%)	134 (11.5%)	0.03	0.523
No. of levels fused†	2.3 ± 3.1	2.4 ± 3.1	0.02	0.713
EBL† *(mL)*	410.5 ± 702.9	428.3 ± 651.3	0.03	0.527
Operative time† *(min)*	229.7 ± 130.1	232.1 ± 126.7	0.02	0.650
Approach *(no. of patients)*				
Anterior	225 (19.4%)	219 (18.8%)	0.01	0.792
Posterior	785 (67.6%)	788 (67.8%)	0.01	0.929
Combined	114 (9.8%)	121 (10.4%)	0.02	0.680
Level of procedure *(no. of patients)*				
Cervical	286 (24.6%)	289 (24.9%)	0.01	0.923
Thoracic	97 (8.3%)	111 (9.6%)	0.04	0.345
Lumbar	838 (72.1%)	822 (70.7%)	0.03	0.494
Drain *(no. of patients)*	697 (60.0%)	719 (61.9%)	0.04	0.372
Complex plastic surgery closure *(no. of patients)*	29 (2.5%)	31 (2.7%)	0.01	0.896

*BMI = body mass index, ASA = American Society of Anesthesiologists, CCI = Charlson Comorbidity Index, COPD = chronic obstructive pulmonary disease, CHF = congestive heart failure, CKD = chronic kidney disease, IA = inflammatory arthritis, MIS = minimally invasive surgery, and EBL = estimated blood loss. †The values are given as the mean and the standard deviation.

with the antibiotics. The sample size and lack of adverse event reporting unfortunately limited that study's ability to assess the risks and benefits associated with postoperative antibiotics.

Dobzyniak et al., in a study of 635 patients undergoing lumbar laminotomy for disc herniation, compared a single preoperative dose of antibiotics (192 patients) with multiple doses of preoperative and postoperative antibiotics (418 patients) and found no difference between the groups in terms of the postoperative infection rate (1.56% compared with 1.20%, respectively; p = 0.71)[12]. The postoperative antibiotic dosing was undefined, and, with an average length of stay of 2 days, it is unclear whether antibiotics were standardized to a 24-hour postoperative period or until discharge. One of the strengths of that study was the sample size; the study was adequately powered at 0.885 to detect differences between the 2 groups. However, the duration of follow-up may have artificially deflated postoperative infection rates as patients' charts were reviewed with a minimum of 6 weeks follow-up, which would have inadvertently missed deep infections presenting 1.5 months after the index procedure.

Several other studies have evaluated the duration of antibiotics in patients undergoing spine surgery; however, there has been wide variation in postoperative antibiotic protocols. Kanayama et al., in a study of 1,597 patients undergoing lumbar spine surgery who received either 1 day of postoperative antibiotics (464 patients) or 5 to 7 days of postoperative antibiotics (1,133 patients), reported no difference between the groups in terms of the infection rate (0.4% versus 0.8%, respectively)[15]. In another study, Kakimaru et al. evaluated patients undergoing microscopic spinal decompression without instrumentation who received no postoperative antibiotic dose (143 patients) or postoperative antibiotics (141 patients)[19]. That study also

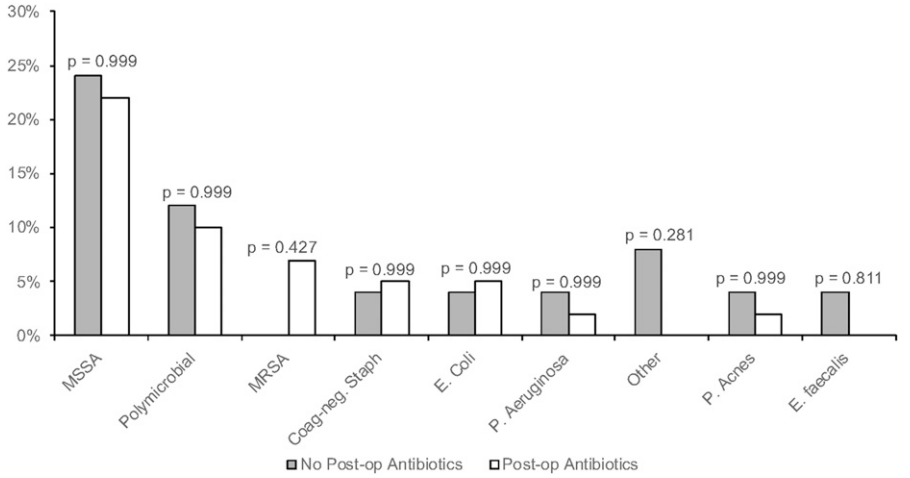

Fig. 2

Culture results after revision surgery for infections in unmatched cohorts. MSSA = methicillin-susceptible *Staphylococcus aureus,* MRSA = methicillin-resistant *S. aureus,* Coag.-neg Staph = coagulase-negative staphylococci, E. coli = *Escherichia coli,* P. Aeruginosa = *Pseudomonas aeruginosa,* P. Acnes = *Propionibacterium acnes* (now reclassified as *Cutibacterium acnes*), and E. faecalis = *Enterococcus faecalis.* Other includes *Enterobacter cloacae, Streptococcus agalactiae,* and *Klebsiella aerogenes.*

demonstrated no added prophylactic benefit in association with postoperative antibiotics in terms of the infection rate (2.8% in the group that received the postoperative dose compared with 1.4% in the group that did not; p = 0.335). The postoperative antibiotic protocol was heterogenous. Some patients received antibiotics throughout postoperative day 0, and some received antibiotics until discharge (average length of stay = 2.7 days). Our study improves on the heterogeneity of those studies in terms of the postoperative antibiotic protocols and adds to the evidence that antibiotics administered after wound closure have no significant effect on preventing infection.

With respect to other orthopaedic surgical procedures, there has been no demonstrated benefit of postoperative antibiotics in addition to a single preoperative dose[11,20-23]. In the hip and knee arthroplasty literature, several studies have shown no difference in infection rates between preoperative-only antibiotic regimens and 24-hour perioperative regimens or between 1-day regimens and 7-day regimens of postoperative antibiotics[11,23]. Tan et al., in a retrospective study of 20,862 primary total hip and knee arthroplasties, found no difference in the postoperative infection rate between patients who received 1 dose of antibiotics and those who received multiple doses[11].

Prophylactic antibiotics have been shown to be most effective if an adequate concentration is maintained within 2 hours after incision[21]. In order to be effective for prophylaxis, antibiotic concentrations in serum, soft tissue, and bone must exceed the minimum inhibitory concentration (MIC) for a specific bacterium[8,21,24]. The MIC must be maintained throughout the duration of the procedure in order to effectively control the bacterial burden[21]. Postoperative antibiotics may be superfluous if the MIC was adequately maintained throughout the procedure.

The administration of antibiotics is not without associated risks. Proper antibiotic stewardship ensures that patients only receive antibiotics when such agents are clinically indicated and have been demonstrated to provide a benefit[21]. The administration of antibiotics beyond the intraoperative period increases financial cost and the long-term risk of multidrug-resistant organisms[21]. Prolonged antibiotic use is also associated with a risk of *C. difficile* infection. Previous laboratory studies have shown that a single dose of cephalosporin antibiotics is sufficient to allow for *C. difficile* colonization, and clinical studies have demonstrated a strong association between cephalosporin antibiotics and *C. difficile* infections[25,26]. However, in the present study, no increased risk of *C. difficile* infection was observed in association with extended antibiotics; this finding was consistent with those reported by Tan et al. for patients undergoing elective total knee and hip arthroplasty[11].

Our study demonstrated no significant increase in multidrug-resistant organisms in patients who received 24 hours of postoperative antibiotics. All patients who demonstrated growth of MRSA on culture had received postoperative antibiotics, although there was no significant difference when compared with those who had not received postoperative antibiotics (p = 0.427). The development of antibiotic-resistant bacteria could occur over a longer period of time than what is captured in our study. The microbial ecosystem of a hospital may have a higher proportion of antibiotic-resistant organisms due to prolonged antibiotic use. However, isolating the impact of extended postoperative antibiotics on an institutional-specific biome is difficult. Antibiotic resistance poses a tremendous challenge to administering effective prophylactic agents and treating surgical site infections. Our study demonstrated no discernible short-term emergence of multidrug-resistant bacteria in patients managed with postoperative antibiotics; however, it did not clarify the broader impact on the hospital biome and the long-term impact on a patient's microbiome caused by more extended antibiotic administration.

The present study improves on the prior literature on the basis of the statistical analysis performed, minimum 1-year

follow-up, standardization of the postoperative antibiotics group, and large sample size with adequate power. With a minimum follow-up of 1 year after the index procedure, we believe that the majority of infections were captured in the data collection[27]. Additionally, all patients who received postoperative antibiotics received the prophylactic agent for 24 hours. Our study is not without limitation as our evaluation was retrospective and therefore was not truly randomized. To address this limitation, we propensity-matched comorbidities to control for any confounding. In addition, there was a low rate of infection with *C. difficile* in our cohort and, as such, it is possible that our study was not adequately powered to detect differences between the 2 groups. The antibiotic regimen, whether a cephalosporin, vancomycin, or clindamycin, was not further pharmacodynamically evaluated to test for differences in clinical outcomes. Finally, our study included all inpatient spinal procedures and, as such, there may be some nuance in outcomes that might be appreciated with more granular data. Future studies should investigate antibiotic use in subgroups of patients undergoing spinal procedures associated with a higher risk of infection, such as revision procedures and procedures for the treatment of deformity.

Conclusions

Our propensity-matched analysis of 4,454 patients undergoing spine surgery demonstrated no additional prophylactic benefit of 24 hours of postoperative antibiotics. In patients who received the additional postoperative antibiotics, there was no increased risk of *C. difficile* infection or short-term emergence of multidrug-resistant organisms. Future studies should further stratify patient populations and identify whether postoperative antibiotics are useful for targeted populations. ■

Matthew V. Abola, MD[1]
Charles C. Lin, MD, MS[1]
Lawrence J. Lin, BA[1]
William Schreiber-Stainthorp, BS[1]
Anthony Frempong-Boadu, MD[2]
Aaron J. Buckland, MD[1]
Themistocles S. Protopsaltis, MD[1]

[1]Department of Orthopedic Surgery, New York University Langone Orthopedic Hospital, NYU Langone Health, New York, NY

[2]Department of Neurosurgery, New York University, NYU Langone Health, New York, NY

Email address for T.S. Protopsaltis: Themistocles.Protopsaltis@nyulangone.org

ORCID iD for M.V. Abola: 0000-0001-8084-3515
ORCID iD for C.C. Lin: 0000-0002-1491-6410
ORCID iD for L.J. Lin: 0000-0002-4102-8590
ORCID iD for W. Schreiber-Stainthorp: 0000-0002-7386-8754
ORCID iD for A. Frempong-Boadu: 0000-0001-5958-0757
ORCID iD for A.J. Buckland: 0000-0003-0275-5020
ORCID iD for T.S. Protopsaltis: 0000-0002-4978-2600

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