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Major Article

Improving compliance with surgical antibiotic prophylaxis guidelines: A multicenter evaluation

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Key Words:
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Background: Improving surgical antibiotic prophylaxis (SAP) use is an important element in the control of antimicrobial resistance. However, compliance with SAP guidelines is unsatisfactory. This study investigated the level of compliance with SAP guidelines in neurosurgery, and institutional characteristics associated with compliance.

Methods: This study assessed surgeries in 9 Brazilian hospitals. Medical record reviews and a structured questionnaire were used to assess compliance and to describe institutional characteristics. Six attributes of compliance with SAP guidelines were evaluated; full compliance was defined whenever all these attributes were met. Logistic and linear regressions were used to investigate the association between compliance, patients, and hospital characteristics.

Results: Full compliance was 10% and was associated with weekly hours of infection control personnel per intensive care unit bed (95% CI, 0.2–0.1), hospital-wide dissemination of SAP guidelines (95% CI, 1.2–25.1), monitoring (95% CI, 1.2–25.1), and feedback of compliance rates (95% CI, 3.8–25.2). Daytime procedures had greater compliance regarding drug dose (odds ratio [OR], 3.38; 95% confidence interval [CI], 1.72–6.65) and initial time (OR, 2.30; 95% CI, 1.24–4.25). Spinal procedures achieved greater compliance with initial time (OR, 1.83; 95% CI, 1.12–3.01) and duration (OR, 1.59; 95% CI, 1.7–2.16).

Conclusions: A low level of compliance was identified, which pointed out the need for an innovative stewardship approach to improve adherence to SAP guidelines. Targeted training programs need to be developed to ensure dissemination of guidelines among surgeons. Monitoring, feedback, and closer interaction between the infection control personnel and the surgical team are key factors for better compliance rates of SAP.

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Surgical site infections (SSIs) are among the major surgical complications and account for approximately 20% of all health care-associated infections (HAIs).¹ These infections increase the length of hospital stay from 7 to 11 days, double the risk of postsurgical death, and account for over one-third of the HAI treatment costs.²

The estimation of the SSI rate related to skull and spine procedures varies from 1.07%–1.51% and from 0.58%–2.04%, respectively. Two meta-analyses found that appropriate usage of surgical antibiotic prophylaxis (SAP) significantly reduced the risk of SSI related

to skull and spine surgery (odds ratio [OR], 0.43; 95% confidence interval [CI], 0.20–0.92³ and OR, 0.37; 95% CI, 0.17–0.78⁴), respectively.

Inadequate SAP usage increases SSI, increases hospital costs, and fosters the emergence of multidrug-resistant strains.^{5–8} Antimicrobial resistance is a global public health threat that has as one of the main causes the massive overuse of antibiotics. In Europe, the prevalence of hospital antibiotic use is 35%.⁹ Over 10% of these prescriptions are destined for SAP,⁹ and more than half of antibiotics are inadequately maintained for >1 day.⁹ In developing countries, the problem may be even more serious. Research conducted in Africa found that >99% of surgical patients received the first dose of SAP after the end of the surgical procedure,¹⁰ whereas a Brazilian study showed only 4.9% of surgical procedures in compliance with local SAP guidelines.¹¹ Nevertheless, there is little information on the appropriate use of antimicrobials for surgical patients in developing countries.

Improving SAP use is an important element in the control of microbial resistance by preventing the selective pressure exerted by

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antimicrobial misuse. The design of effective SAP improvement strategies needs to be based on the understanding of the factors that are associated with compliance. Hence, observational studies might be the first step toward implementation of programs to achieve higher levels of SAP compliance.

Local evidence-based guidelines are essential to promote the correct use of SAP. However, the sole existence of SAP guidelines does not ensure compliance.^{12,13} In a previous study, we identified failures in the effective application of institutional guidelines.¹¹ Despite the profusion of literature about the subject^{5-8,14} few studies have been undertaken addressing factors associated with better SAP compliance and, particularly, regarding SAP use in neurosurgery.^{8,11,15} This study aims to determine the index of SAP compliance in neurosurgery and to identify institutional characteristics associated with better compliance.

MATERIALS AND METHODS

Study design

A retrospective cross-sectional study was carried out involving 9 tertiary care hospitals, public and private, located in São Paulo city, Brazil. São Paulo, the largest city in the Americas, with approximately 11 million inhabitants, has 148 general hospitals according to the national register of hospitals at the time of the project design (<http://cnes.datasus.gov.br>).

Settings and sampling

The inclusion criteria for hospitals were defined as follows: at least 100 procedures of neurosurgery performed in 2010 and having medical records of adult (≥ 18 years) neurosurgical patients submitted to clean surgical procedures for which SAP was indicated, involving the skull or spine. All the 31 hospitals that met these criteria were invited to participate. The invitation was carried out by telephone contact directly to members of the hospital infection control committees (HICCs). Nine hospitals accepted the invitation and were included in the sample. The sample size for medical records within each hospital was calculated based on the total number of procedures performed in the facility in 2010, with an expected compliance rate of 40%, resulting in a sample of 1,459 clean surgical procedures to be assessed. The medical records were randomly selected by using a randomization table. Procedures for hospital selection and invitation, ethical approvals, and sampling were performed between 2011 and 2012.

Data collection

Data collection was performed by the principal investigator (C.S.) and by 3 trained nurses from August 2013–September 2014. The year of 2010 was used as the reference for data collection. Compliance was defined as the agreement of procedures to SAP guidelines available at the hospital. The assessment of compliance focused on the effective application of institutional SAP guidelines, with no attempts to evaluate the quality of institutional guidelines. Only SAP guidelines formally approved by the HICC were considered. Data regarding SAP compliance, patient characteristics (age, sex, and American Society of Anesthesiologists score), type of procedure, time of procedure (day or night), day of the week (weekday or weekend), and duration of procedure were gathered from the medical records of neurosurgical patients.

The assessment of compliance with SAP was composed of 6 attributes, which were checked against each HICC internal guideline: (1) the appropriate indication of antibiotic, (2) the drug type, (3) the duration of prophylaxis (ie, the time from the first dose to

the last one), (4) the administration route, (5) the initial time of antibiotic prophylaxis (administration within 60 minutes of surgical incision), and (6) the drug dosage. A full compliance index was met only when all 6 attributes of SAP were compliant with the respective HICC guidelines, resulting in a dichotomous outcome: compliance or noncompliance.

A structured questionnaire was applied to the HICC members by means of an interview to access institutional characteristics regarding overall number of beds, intensive care unit (ICU) beds, type of funding (public or private), and the existence of any external quality accreditation. The HICC members interviewed were designated by the hospital administration. The HICC was characterized according to time length of its establishment, number of dedicated professionals and their formal education, and weekly working hours. The existence of established guidelines, frequency of their updating, dissemination strategies, frequency of SAP training sessions, and existence of outcome and process indicators regarding SSI rate and compliance with SAP protocols were investigated.

Data analysis

A logistic regression was carried out to analyze the association between compliance with SAP attributes (dichotomous outcome variables) and the characteristics of surgical procedures. The association between hospital characteristics and SAP compliance index (continuous outcome variables) was assessed through linear regression. For both linear and logistic regression, the associations were adjusted for all variables in the model accordingly. All analyses were conducted assuming a CI of 95% using Stata 12.0 (Stata Corp., Brownsville, TX).

Ethics

The research was approved by the Ethics in Research Committee of the School of Nursing, University of São Paulo (protocol no. 73611) and by the ethics committee of each hospital.

RESULTS

Institutional characteristics

Nine hospitals with capacities between 156 and 800 beds were evaluated; among them, 6 were private and 3 were public settings. Five hospitals had quality certification by an external board of evaluation. The average time of establishment of the HICC was 21.9 years (range, 10-39). All hospitals had at least 1 physician and 1 nurse dedicated to the HICC. The mean weekly working hours of HICC-dedicated personnel per bed was 0.5 hours (range, 0.2-0.9 hours), and per ICU bed was 2.9 hours (range, 1.2-6.0 hours).

The 9 evaluated hospitals performed 3,253 neurosurgical procedures in 2010. The number of neurosurgical procedures ranged from 138-1,057, with a mean of 361. A total of 1,011 surgical procedures were assessed, including 451 (44.6%) craniotomies, 325 (32.1%) spinal fusions, 196 (19.4%) laminectomies, and 39 (3.9%) other procedures. Slightly more than half of the patients were men (50.5%), with a mean age of 50 years (range, 18-94 years).

All hospitals had SSI prevention guidelines, which were updated at least every 1-2 years. The guidelines showed variations among the evaluated hospitals. Most of the guidelines recommended second-generation cephalosporins. However, recommendations of third-generation cephalosporins or glycopeptides for patients with long-term hospitalization (≥ 5 days) were identified. Duration of SAP ranged from a single dose up to 5 days. In 6 hospitals, the HICC team stated that guidelines were hospital-wide disseminated, promoting that nearly all professionals knew the institutional guidelines. The guidelines were available in hard copies, digital format, or both

Table 1

Compliance to attributes of surgical antibiotic prophylaxis in 9 hospitals, São Paulo, Brazil, 2016

Attribute	Surgical procedures
Indication	907/1,011 (90.0)
Dose*	818/903 (90.6)
Drug type	582/907 (64.2)
Initial time of antibiotic prophylaxis†	
Compliant	504/654 (77.1)
Too early	48/654 (7.3)
Too late	102/654 (15.6)
Duration of antibiotic prophylaxis‡	
Compliant	236/905 (26.1)
Too short	106/905 (11.7)
Too long	563/905 (62.2)
Full compliance§	98/973 (10.0)

NOTE. Values are number compliant/number assessed (%).

Too early, >60 minutes before the incision; Too late, after the incision.

*Excluded procedures without antibiotic use (n = 104), and no data available (n = 4).

†Excluded procedures without antibiotic use (n = 104), and no data available (n = 253).

‡Excluded procedures without antibiotic use (n = 104), and no data available (n = 2).

§No data available (n = 38).

in all hospitals. Six hospitals submitted the SAP guidelines for formal approval by the surgical team before dissemination. Four hospitals performed training on SSI prevention only in response to demand from health care teams or during outbreak situations. All hospitals monitored SSI rates in clean surgical procedures; in 8 of them, feedback on global rates was given to health care professionals, and in 7, rates were stratified by surgical specialty. In 4 hospitals, the HICC assessed SAP compliance by reviewing medical records and giving feedback to the surgical team.

Compliance with SAP guidelines

In 104 (10.3%) cases, despite the HICC recommendation for prophylactic antibiotics, the information about use was not found in medical records. Overall, full compliance with SAP guidelines (compliance with the 6 attributes) occurred in 10% of the assessed procedures (range, 0%-28.9%) (Table 1). However, full compliance index was markedly heterogeneous when procedures were stratified (14.1% of spinal fusions, 10.7% of laminectomies, 7.6% of craniotomies, and 2.6% of other procedures). In 38 surgical procedures, it was not possible to determine full compliance because of the unavailability of data regarding ≥1 parameters of compliance evaluation.

The administration route was intravenous in all cases. The SAP attributes to which there was greater compliance were dose (90.6%), indication (90.0%), and initial time of antibiotic prophylaxis (77.1%). The SAP was started after the incision in 102 (15.6%) procedures. The main flaw in compliance was related to the duration of the SAP, which was compliant in only 26.1% of the procedures, having an excessive duration in 62.2% of them (Table 1).

Institutional characteristics and SAP compliance index

The full compliance index for SAP had an association with the weekly hours of infection control personnel per ICU bed (95% CI, 0.2–0.1), hospital-wide dissemination of SAP guidelines (95% CI, 1.2–25.1), monitoring of compliance (95% CI, 2.4–25.2), and feedback to stakeholders and surgical team about SAP compliance index (95% CI, 3.8–25.2) (Table 2). The variables of age, sex, American Society of Anesthesiologists physical status classification, weekday, and duration of surgery had no association with full compliance index or specific compliance to any attribute.

Compliance with attributes such as dose and initial time of SAP was greater when surgical procedures were performed during the

Table 2

Hospital characteristics associated with full compliance index (9 hospitals) using multivariate linear regression analysis, São Paulo, Brazil, 2016

Variable	Regression coefficient	95% CI	P value
Hospital >500 beds	-0.9	-20.9 to 19.1	.917
Private hospital	-2.7	-20.2 to 14.8	.725
Quality accreditation	-0.4	-6.2 to 6.2	.988
HICC weekly working hours per bed	11.4	-31.6 to 54.5	.551
HICC weekly working hours per ICU bed	4.6	0.2 to 0.1	.048
HICC physicians' weekly hours	0.1	-0.1 to 0.3	.376
HICC nurses' weekly hours	0.0	-0.1 to 0.1	.778
HICC length of existence (y)	-0.3	-1.5 to 0.9	.578
Hospital-wide dissemination of SSI guidelines*	4.4	-7.1 to 15.9	.392
SAP approved by the surgical team	8.2	-7.9 to 24.2	.270
Periodic review of SAP guidelines	6.6	-12.6 to 25.7	.445
Hospital-wide dissemination of SAP guidelines*	13.2	1.2 to 25.1	.035
Audit of compliance with SAP	13.8	2.4 to 25.2	.024
Feedback† of SAP guidelines compliance index	14.5	3.8 to 25.2	.015
Feedback† of SSI rate	-8.4	-33.9 to 17.0	.459

NOTE. The associations were adjusted for all variables in the table accordingly. CI, confidence interval; HICC, hospital infection control committee; ICU, intensive care unit; SAP, surgical antibiotic prophylaxis; SSI, surgical site infection.

*By hard copies, digital means, or both.

†The team was informed about the rates periodically.

daytime compared with the night (OR, 3.38; 95% CI, 1.72–6.65 and OR, 2.30; 95% CI, 1.24–4.25), respectively. Procedures involving the spine were more likely to be in compliance with respect to both attributes of initial time (OR, 1.83; 95% CI, 1.12–3.01) and duration (OR, 1.59; 95% CI, 1.7–2.16) of SAP (Table 3).

DISCUSSION

Our study demonstrated that compliance with SAP guidelines remains a problem. According to the literature, compliance seems to be lower in neurosurgery than in other procedures. An Italian study that assessed 717 surgical procedures found SAP compliance in overall procedures of 44.8%, but only 5.3% in neurosurgery.¹⁵ Likewise, in studies carried out in Qatar and Brazil, the SAP compliance was higher for other specialties than for neurosurgery, being, respectively, 46.5% versus 6.4% and 4.9% versus 3.1%.^{8,11} However, despite the low level of full compliance identified in our research, it was higher than those described elsewhere for neurosurgical procedures.^{8,11,15}

As in other studies,^{5,11} higher compliance was found in relation to the attributes of dose and indication. The lowest compliance was related to SAP duration, which was mainly longer than recommended, suggesting potential disagreement of the surgical team with HICC guidelines. This may be caused by a misconception by surgeons that extending SAP could reduce the risk of SSI. Similar low rates of compliance regarding duration were described in studies from Qatar (31%), Nicaragua (22%), and Brazil (5%).^{6,8,11,14} This highlights the waste of valuable antimicrobial resources worldwide.

Misuse of SAP, mainly longer than recommended, raises antibiotic consumption, changes individual and institutional bacterial flora, and predisposes patients to *Clostridium difficile* disease.¹⁶ Between 2000 and 2010, the global consumption of antibiotics increased 36%, with the largest increases being in countries such as Brazil, Russia, India, China, and South Africa. However, the misuse of antibiotics is not restricted to developing countries, also affecting developed countries such as the United States, New Zealand, and Australia.¹⁷

Contrary to our expectations, the variables, such as the type of hospital funding, quality accreditation by external agencies, overall

Table 3

Surgical procedures and patient characteristics associated with SAP attributes compliance using multivariate logistic regression analysis, São Paulo, Brazil, 2016

Variable	Full compliance		Indication		Drug type		Drug dosage		Initial time of SAP		Duration of SAP	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Age	1.00	0.98-1.01	1.00	0.98-1.01	1.01	1.00-1.02	0.99	0.97-1.01	1.00	0.99-1.02	0.99	0.98-1.00
Sex	1.09	0.66-1.80	0.80	0.48-1.35	1.03	0.74-1.43	0.75	0.42-1.33	0.86	0.56-1.32	1.19	0.82-1.72
ASA	1.11	0.77-1.58	0.81	0.59-1.13	0.90	0.72-1.12	1.07	0.74-1.55	0.83	0.62-1.10	1.15	0.89-1.49
Spine surgery	1.55	0.86-2.82	1.76	0.95-3.28	1.27	0.87-1.84	1.64	0.84-3.17	1.83	1.12-3.01	1.68	1.09-2.59
Daytime surgery	1.56	0.61-3.90	1.28	0.65-2.51	1.05	0.61-1.80	3.38	1.72-6.65	2.30	1.24-4.25	1.30	0.70-2.43
Business day surgery	1.27	0.65-2.47	0.76	0.39-1.46	1.56	0.97-2.52	0.92	0.43-1.94	1.13	0.60-2.13	0.91	0.51-1.50
Duration of surgery	0.99	0.99-1.00	1.00	1.00-1.00	0.99	0.99-1.00	1.00	0.99-1.00	0.99	0.99-0.99	0.99	0.99-1.00

ASA, American Society of Anesthesiologists; CI, confidence interval; OR, odds ratio; SAP, surgical antibiotic prophylaxis.

weekly working hours of dedicated infection control personnel, HICC time of existence, hospital-wide dissemination of SSI guidelines, and periodic updating of SAP guidelines, had no association with full compliance.

We know from others' experience that surgical team disagreement with SAP guidelines is a barrier to compliance. In a Spanish study that assessed 1,395 surgical procedures, 28% of the reasons for non-compliance were about disagreements with the recommendations.¹⁸ Another study involving 1,763 surgical procedures and 13 hospitals, also reported surgical team disagreements with SAP guidelines.⁷ However, our study found that the formal approval of the SAP guidelines by the surgical team was not associated with higher full compliance. This suggests that formal approval is not enough to ensure the effective adherence to SAP guidelines by the surgeons.

Our study identified a set of factors associated with better compliance with SAP guidelines. Confirming our initial hypothesis, audit and feedback were associated with the highest SAP compliance index, which are in agreement with other studies.¹⁹⁻²² A systematic review showed an improvement on the practice of health care professionals up to 70% when audit and feedback were performed; greater improvement was achieved when baseline compliance rate was low and feedback was intensively delivered.¹⁹ Another study carried out in the United States involving 3,087 hospitals revealed significant performance improvement in 15 of 18 measures regarding the quality of care for acute myocardial infarction, heart failure, and pneumonia, without significant deterioration for any of the evaluated measures.²⁰ Likewise, a Korean study involving hospitals with >100 beds evaluated the compliance regarding drug type, initial time of SAP, and duration. The compliance with the 3 indicators was significantly higher after the implementation of a national hospital evaluation program.²² Of note, the implementation of an internal program of audit and feedback is a relatively inexpensive tool that promotes engagement of professionals in this matter. Additionally, feedback might be an opportunity to provide data to establish a benchmarking for health care practices, fostering improvements.

Weekly working hours of dedicated infection control personnel per ICU bed showed an association with full compliance. This can be explained by the fact that most neurosurgical patients were admitted to the ICU immediately after surgery. Therefore, more time spent by the infection control personnel in the ICU has enabled closer interaction with the care teams, allowing proper intervention on the duration of SAP in the postoperative period. Sekimoto et al²¹ detected better HICC performance, including more clinical meetings and staff hours, being associated with compliance. A Brazilian study involving 25 hospitals also showed that hospitals with a higher number of HICC professionals are more efficient in prevention and control of HAI.²³

When designing our research project, we have hypothesized that night shifts and weekends or holidays would interfere with SAP compliance. We indeed found that surgical procedures performed during the day were more compliant regarding dose and initial time of SAP

than those performed during the night. The influence of work shift in the compliance with infection control measures was also evidenced by a Brazilian study on hand hygiene. Santana et al identified lower rates of hand hygiene compliance in the night shifts but not on weekends or holidays.²⁴ These results may be explained by the fewer number of professionals working night shifts, which might be associated with either flaws in the process or lack of knowledge of the SAP guidelines.

As demonstrated by Italian, Greek, and Spanish studies,^{15,18,25} we also found heterogeneity in the SAP compliance index between the different types of procedures. A Greek study showed lower SAP compliance in aortic aneurysm repair than in vascular surgery, despite the surgical procedures being performed by the same surgeons.²⁵ In our study, there was greater compliance in procedures involving the spine regarding the initial time and SAP duration.

In this study, data were collected retrospectively, and some missed information may have imposed limitations on our study. However, a prospective study would be infeasible because of the costs and time required for data collection.

The strength of our study is the enrollment of 9 hospitals, representing SAP practices in both public and private hospitals, with potential for generalization, which provides guidance for other similar economic and cultural contexts.

This study demonstrated a low level of compliance with guidelines, mainly regarding SAP duration, resulting in extra costs and unnecessary exposure to antibiotics. This pointed out the need of an innovative stewardship approach to improving adherence to SAP guidelines, to prevent HAI and to avoid selection pressure for antimicrobial resistance. In addition, targeted training programs need to be developed to ensure dissemination of guidelines among surgeons. Monitoring and feedback, and closer interaction between the infection control personnel and the surgical team, are key factors for better compliance rates of SAP.

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