Implementing 1-Dose Antibiotic Prophylaxis for Prevention of Surgical Site Infection

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Hypothesis: Replacing a 24-hour regimen with a 1-dose antibiotic prophylaxis for elective surgery would not increase rates of surgical site infection and would decrease costs.

Design and Setting: Before-after trial in a tertiary, private general hospital in Ribeirão Preto, São Paulo, Brazil.

Patients: Surgery was performed on 6140 consecutive patients from February 2002 through October 2002 (period 1) and 6159 consecutive patients from December 2002 through August 2003 (period 2). Studied surgeries included orthopedic, gastrointestinal, urology, vascular, lung, head and neck, heart, gynecologic, oncology, colon, neurologic, and pediatric surgeries. The study excluded patients with infection at the time of surgery.

Intervention: Decreasing the 24-hour prophylactic antibiotic regimen to 1-dose antibiotic prophylaxis.

Main Outcome Measures: Surgical site infections in both periods measured by in-hospital surveillance and postdischarge surveillance; compliance with 1-dose prophylaxis; and costs with cephazolin.

Results: We followed up 12,299 patients during their hospital stay; postdischarge surveillance increased significantly from 2717 patients (44%) to 3066 patients (50%, P < .001). One-dose prophylaxis was correctly followed in 6123 patients (99% compliance). The rate of surgical site infection did not change in either period (2% and 2.1% respectively, P = .67). The number of cephazolin vials purchased monthly decreased from 1259 to 467 with a corresponding monthly savings of $1980.

Conclusions: One-dose antibiotic prophylaxis did not lead to an increase in rates of surgical site infection and brought a monthly savings of $1980 considering cephazolin alone. High compliance to 1-dose prophylaxis was achieved through an educational intervention encouraged by the hospital director and administrative measures that reduced access to extra doses.

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Despite the knowledge about preventing infection and despite the progress of contemporary surgery, infection is still one of the most feared complications of a surgical procedure. Perioperative antimicrobial prophylaxis has long been advocated in certain types of clean and clean-contaminated surgical procedures to decrease the incidence of surgical site infections (SSIs). Burke,¹ in a classic experimental study, demonstrated not only the efficacy of antibiotics in preventing SSI but also that there is a time frame during which the antibiotics should be given to be effective, essentially having antibiotic levels in the blood only just prior and during the procedure itself. Numerous guidelines²⁻⁸ for the correct use of prophylactic antibiotics have been published in recent years; those guidelines and publications show that 1-dose prophylaxis is efficacious for most procedures. Unfortunately, experience has shown that surgeons’ compliance with these recommendations can be hard to obtain.⁹⁻¹５ More recently, Bedouch and colleagues¹⁶ showed that compliance with antibiotic prophylaxis guidelines in total hip replacement surgery occurred in only 53% of the procedures in a French teaching hospital.

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Increasing health care costs have led (or forced) hospitals and clinics to review procedures to adjust their budgets. Also, concerns with antimicrobial resistance have pressured infection control specialists to decrease antimicrobial usage. We previously described¹⁷ the successful imple-
implementation of an antibiotic prophylaxis program in our hospital, discontinuing prophylactic antibiotic usage after 24 hours and correcting the timing of the first dosage. We decided to reduce all antibiotic prophylaxis to 1 dose because this measure could safely promote savings for our institution. We hypothesized that the SSI rate would not increase when we used fewer antibiotics, and we intended to demonstrate that by comparing SSI data collected by in-hospital surveillance and postdischarge surveillance (PDS) before and after implementing the program. This article describes the implementation of 1-dose prophylaxis (ODP), surgeons' compliance, and effect on SSI rates.

**METHODS**

Hospital São Francisco is a 180-bed general hospital that serves Ribeirão Preto, the third largest city in the state of São Paulo, Brazil. Its average daily census is 150; 500 to 600 surgeries, mostly elective and most from the major specialties, are performed each month. Around 70% of all procedures are from the orthopedic, gastrointestinal, urology, and vascular services. The study period was from February 2002 through August 2003. Period 1 (before ODP) went from February 2002 to October 2002 and period 2 went from December 2002 through August 2003. We planned to study antibiotic use and surgical infections in all surgeries performed during the study period, reviewing data on 12 299 surgeries. Infections were discovered by in-hospital surveillance that was done by consulting all the antibiotic prescription forms and culture results daily and by visiting the intensive care units and wards regularly, seeking infections. Postdischarge surveillance was done by the infection control nurse by telephoning patients 10 to 15 days after hospital discharge. The nurse followed a chronological list of patients who had operations each month and attempted to telephone each patient twice a day from Monday through Saturday. During this phone call, she asked infection-related questions focusing mainly on signs and symptoms of SSI. If symptoms or signs of infection were determined (fever, surgical incision with purulent drainage, or new antibiotic prescriptions focusing mainly on signs and symptoms of SSI), the nurse's medical record was consulted and the surgeon was contacted with any questions related to the infection diagnosis. A positive contact was defined as a patient who answered the phone call and gave complete answers to the infection-related questions. In some instances, surgeons sought an infectious disease consultation with one of us to manage difficult cases. We used the definitions for SSI described by the Centers for Disease Control and Prevention.18 There was no change in surveillance methods during the study period, but there was an effort to reach more patients each month. The proportion of positive contacts was calculated by dividing the number of contacted patients by the total number of surgical patients. The SSI rate was calculated by dividing the total number of SSIs by the total number of surgeries. The proportion of SSIs detected by PDS was calculated by dividing the number of SSIs detected by PDS by the total number of SSIs.

## PROTOCOLS

Based on published guidelines,24 protocols of antibiotic prophylaxis (choice of antibiotic, dose, route, timing of the first dose, redosing if necessary, and options for the allergic patient) were rewritten and implemented in November 2002. The new 1-dose protocol defined that in most surgeries, 1 g of cefazolin would be given at anesthesia induction. No doses would be given after the end of surgery. Protocols were approved by surgeons in previous meetings headed by the clinical director, himself a surgeon. Education regarding the program was provided to anesthesiologists, residents, nursing personnel, and medical staff of all clinics before and during the implementation of the program. Education consisted of oral presentations with written references available; also the infectious disease specialists were available through cell phones and beepers to answer questions. For 3 consecutive monthly infection control committee meetings, the subject of prophylactic antibiotics was discussed at length with all committee members.

## ODP PROGRAM

For each surgical procedure in which prophylaxis was recommended, all the necessary antibiotic vials were dispensed in a plastic bag at the operating room with a preprinted prescription for the patient. The dose was always given by the anesthesiologist at anesthesia induction. If the surgeon wanted to modify the prophylaxis with a different drug or to extend the prophylaxis beyond the operating room, the surgeon had to fill out an antibiotic form (AF) before the drug was released from the pharmacy.

## ODP COMPLIANCE

All operations in which an AF was not used were considered compliant because it was not possible to get any antibiotic vial without filling out an AF. Compliance with the new protocol was therefore measured based on the proportion of operations in which an AF was not used.

## ODP TIMING

A random sample of heart surgeries, orthopedic surgeries with prostheses, and neurosurgery was studied to determine the exact timing of the first dose of prophylaxis during period 2. We considered an appropriate ODP a prophylactic antibiotic that was given at anesthesia induction up to 1 hour after surgery.

## USE OF CEPHAZOLIN

In our hospital, cefazolin is used only for prophylaxis. The costs of all 1-g cefazolin vials purchased in both periods were determined, assuming a value of $2.50 for each 1-g cefazolin vial. The number of purchased vials of cefazolin was determined for period 1 and period 2.

## STATISTICAL ANALYSIS

The proportion of positive contacts, the proportion of infections discovered by PDS, and the SSI rate were compared in period 1 and period 2 by the χ² method.19 A P value of less than .05 was considered significant.

## RESULTS

During period 1 and period 2, 6140 surgeries and 6159 surgeries were performed, respectively. There were 127 SSIs (rate, 2%) and 133 SSIs (rate, 2.1%) in period 1 and period 2, respectively. Postdischarge surveillance detected 90 SSIs (71%) and 97 SSIs (73%) in periods 1 and 2, respectively. More detailed information appears in **Table 1** and **Table 2**. The total number of procedures remained relatively constant throughout the study peri-
ods; the distribution of procedures among the different specialties remained approximately the same. We did not change our in-hospital surveillance method during the study, so we assumed that all SSIs recognized as such by the surgeon (prescribing antibiotics and/or requesting microbiology cultures) were also detected by us. The number and proportion of contacted patients by PDS, however, significantly increased in period 2. In period 1, 2717 patients (+4% of total) were contacted by phone; in period 2, 3066 patients (30%) were telephoned. Rates of SSI nevertheless were comparable in both periods.

Surveillance for SSI is a standard procedure in many hospitals, and the United States has a countrywide surveillance system.\(^{20}\) Surgical site infections increase morbidity and mortality and can bring considerable costs to an already overwhelmed health care system.\(^{21,22}\) A recent study\(^ {23}\) showed that SSI in an elderly population causes a 2-fold increase in hospital charges, adding an extra $41,000 to mean attributable charges per SSI. Perencevich and colleagues\(^ {24}\) looked at clinical outcomes and resource usage in the 8-week postoperative period associated with SSI recognized after discharge, determining that the average total costs during those 8 weeks after discharge were 3 times higher in infected patients compared with uninfected patients ($5155 and $1773, respectively).

Moreover, SSI rates have increasingly been used as a measure of quality of care in hospitals. The Healthcare Infection Control Practices Advisory Committee (HICPAC) from the Centers for Disease Control and Prevention has recently published its document in response to the movement toward public disclosure of nosocomial infections.\(^ {25}\) It recommends that mandatory public reporting systems for nosocomial infections select 1 or more process or outcome measure. Rates of SSI for selected operations are among the recommended outcome measures, and compliance with surgical antimicrobial prophylaxis guidelines is one of the recommended process outcomes.

For a long time, surgical prophylaxis has been advocated to decrease SSI rates; numerous guidelines have been published recommending 1 dose of a narrow-spectrum prophylactic antibiotic given just before surgical incision.\(^ {1,4,26}\) However, it has been recognized that very often surgeons do not comply with short courses of prophylactic antibiotics or they use broad-spectrum antibiotics.\(^ {13,15,27}\) Misuse of antibiotics is not harmless;
increasing adverse effects, bacterial resistance, and costs are among a few problems commonly associated with antibiotic use. To our knowledge, no one has demonstrated that an increase in adverse effects was seen using surgical prophylaxis for 24 hours. Kreisel and colleagues examined a possible relationship between prophylactic antibiotic therapy and the development of Clostridium difficile toxin positivity by studying retrospectively 357 patients with positive test results for C difficile toxin. They found that 6% had received prophylactic antibiotics and that the majority of these patients (58%) had received prophylactic antibiotics inappropriately. The odds ratio for the development of C difficile toxin positivity from inappropriate use of prophylactic antibiotic was 5.1 (95% confidence interval, 1.10-23.64).

An appealing argument for decreasing antibiotic usage may involve cost. There are publications in the literature showing substantial savings with less antibiotic usage. To our knowledge, this is the first study to demonstrate that adjusting 24-hour prophylaxis to ODP reduces costs without increasing infection rates and results in a potential monthly savings of $20000. It is important to notice that our savings referred only to decreasing surgical prophylaxis from 24 hours to ODP, which meant decreasing 2 to 3 doses per surgery. In hospitals where prophylaxis lasts more than 24 hours, the savings may be even larger. In countries with limited resources such as Brazil, even relatively modest savings can have an impact.

Implementing an appropriate prophylaxis program has been tried and has been successful in many cases and unsuccessful in others. Brusaferro and colleagues were able to document only a modest increase in the proportion of correct surgical antimicrobial prophylaxis from 31% to 45%; Kim reported low compliance (36%) with prophylactic antibiotic advisory consultation in the surgical clinics, the lowest compliance when compared with therapeutic antibiotic advisory consultation in other medical and surgical patients. Understanding the difficulties involved in prescribing prophylactic antibiotics correctly is a key feature of changing this discrepancy between knowledge and clinical practice.

We intended to assess compliance with ODP and to demonstrate to our surgeons with local data that the SSI rate would not increase by using less antibiotic for prophylaxis. Cephazolin is the suggested prophylactic antibiotic in our hospital; the high compliance with the protocol during period 2 and the substantial decrease of purchased cephazolin vials demonstrated that ODP was in fact implemented in our hospital.

Rates of SSI are better determined with PDS. Our data showed that more than 70% of SSIs were detected by PDS. Because the proportion of contacted patients increased significantly in the period using ODP, surgeons felt confident that using less antibiotic did not have a negative impact on the SSI rate.

We attributed the successful implementation of our prophylaxis protocols to the important support of our administration and the enthusiastic encouragement by the clinical director, himself a respected surgeon. His role as the leader in the program implementation was a key feature of convincing surgeons to adhere to the new protocols. A similar experience was reported by Everitt and colleagues, who developed an educational intervention aimed at the choice and appropriate dosing for antibiotic prophylaxis in cesarean deliveries. They targeted their educational efforts to authoritative senior department members and obtained a substantial improvement in the choice of antibiotics in less than 3 years. Savings were estimated to be more than $26 000 each year. The idea of using an antibiotic for prophylaxis that is not readily available for therapeutic use may also have a role in the successful compliance rate.

Our study has some limitations. First, we did not study the patients who underwent surgery to assess if both groups of patients were comparable. Because no substantial modification of the general patient population occurred in 2002 and 2003, no important modification of the distribution of surgical procedures happened, and because of the large numbers of patients studied, it is possible that no such bias occurred. Second, the sample of studied surgeries for correct timing was small and restricted to long-lasting clean surgeries; 66% of such surgeries were revised and compliance with correct timing reached 93%. It is our understanding that more surgeries have to be followed up to assess correct timing and to ensure 100% compliance. It is also possible that some infections were missed in the process. Finally, this study was not designed to assess the validity of ODP guidelines for all surgeries in all hospitals because in special situations multiple dosing may be needed, but it can help surgeons believe that ODP is safe and feasible to implement.

We were able to demonstrate that ODP is feasible. In this era of restricted hospital budgets and increased bacterial resistance, ODP may provide a way to improve performance by lowering costs.

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