

Compliance with surgical antibiotic prophylaxis guidelines: a prospective descriptive study at a tertiary level hospital in Cape Town, South Africa

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Background: The aim of surgical antibiotic prophylaxis (SAP) is to prevent surgical site infection (SSI) by administering an appropriate antimicrobial agent perioperatively. However, SAP may be associated with adverse effects and incurs added costs. The primary objective of this prospective study is to establish whether clinicians are adhering to existing perioperative antibiotic prophylaxis guidelines in terms of indication, dosage and timing of SAP. Secondary objectives are to determine the proportion of patients receiving inappropriate antibiotics, and to evaluate correct practice concerning re-dosing and duration of SAP.

Methods: A cross-sectional prospective audit of the anaesthetic records and prescription charts of surgical patients was conducted at Groote Schuur Hospital, a tertiary level teaching hospital in Cape Town, South Africa, over a period of one week. Data were collected by anaesthetists – blinded to the study objectives – and the investigators; then captured on Excel spreadsheets and compared to existing SAP guidelines. Descriptive statistics and binary logistic regression were used for analysis.

Results: Of the 192 patients consented, 180 questionnaires were completed for data analysis. The median age of participants was 44.5 years (IQR: 31.5–58), with a preponderance of females (58.7%). SAP was administered in 149 cases (82.8%) and withheld in 31 (17.2%). This was appropriate in 91.9% (137/149) and 77.4% (24/31) respectively. Twelve patients (6.7%) received inappropriate antibiotics and in seven (3.9%) it was inappropriately withheld. Of the 156 patients who should have received SAP, choice of drug was correct in 121 (77.6%), dosage in 110 (70.5%) and timing in 87 (55.8%). Absolute compliance was achieved in 44.4% (80/180). Errors were mostly related to timing, re-dosing and duration of SAP.

Conclusion: Anaesthetists and surgeons at Groote Schuur Hospital demonstrate variable adherence to surgical antibiotic prophylaxis guidelines. Interventions aimed at improving compliance are warranted.

Keywords: surgical antibiotic prophylaxis, adherence, compliance, guidelines, surgical site infection

Background

Surgical antibiotic prophylaxis (SAP) entails the prevention of infectious complications by administering an appropriate antimicrobial agent prior to exposure to contamination during surgery. However, a delicate balance exists between causing and preventing harm. In the setting of SAP, the risk:benefit ratio revolves around balancing the risk of adverse drug reactions and microbial resistance against the benefit of reduced incidence of surgical site infection (SSI). Therefore, optimising SAP may contribute towards cost saving benefits, improved patient outcomes and responsible antibiotic stewardship.

The term SSI encompasses the surgical wound and associated infections occurring within 30 days after a surgical procedure, or up to a year later in case of an implant. It is classified as superficial infection, deep infection, organ space infection or sepsis.¹ The worldwide incidence is 2–5% with a peak incidence of 20% for colon surgery.² It is the third most common cause of nosocomial infection and the most common among surgical patients,³ contributing to the burden of disease by increasing duration of hospitalisation and consequently, cost. According to the American College of Surgeons and Surgical Infection Society, SSI

incurs the highest cost of all nosocomial infections, extending length of stay by 9.7 days on average.²

The aim of SAP is to prevent SSI by administering an antibiotic that targets the microbes most likely to contaminate the surgical site, achieving adequate and timeous tissue levels and maintaining this for the duration of the surgery; whilst reducing adverse effects and microbial resistance by employing the narrowest possible spectrum of antibiotic for the shortest possible period (or omitting where appropriate).^{1,4-6} The purpose of SAP guidelines is to establish such sound practices, but in 2018 a prospective descriptive study conducted at another South-African academic hospital demonstrated that anaesthetists' utilisation and knowledge of SAP guidelines were lacking: only 15.6% followed any given guideline in their practice and the mean score for knowledge was 56.2%.⁷ From national and international guidelines, six defining aspects of SAP compliance emerge, namely: indication (to administer or withhold), choice/selection (appropriate spectrum), dosage, timing, re-dosing and duration (correct continuation/discontinuation).^{1,5,6,8,9} Reasons for non-compliance revolve around issues relating to clinicians' knowledge, attitude, beliefs, team communication and

allocation of responsibilities, as well as institutional promotion, support and monitoring of SAP.¹⁰

A prospective, international, multicentre cohort study by the GlobalSurg Collaborative highlights several issues of concern around SAP and SSI: most notably the relatively greater risk of SSI and higher rates of microbial resistance against SAP, compounded by the paucity of high quality research emerging from countries with a low human development index (HDI) as opposed to those with a middle- or high HDI.¹¹ As there appears to be an urgent need for both research and intervention as far as the SAP practice of South African clinicians is concerned, the primary objective of this study was to establish the compliance with existing SAP guidelines in terms of indication, selection, dosage and timing of SAP. Secondary objectives were to determine the proportion of patients receiving antibiotics inappropriately, and evaluate re-dosing and duration of SAP.

Methodology

A cross-sectional prospective descriptive research design was used for this facility-based study. Ethical approval was obtained from the Human Resources Ethics Committee (HREC) of the University of Cape Town, South-Africa (HREC 757/2017).

The study population consisted of adult patients over eighteen years of age presenting to Groote Schuur Hospital for surgery. All surgical subspecialties were included. Recruitment took place during one week from 07h00 on Monday until 19h00 on Friday.

This SAP audit was based on the Scottish Intercollegiate Guidelines Network (SIGN) recommendations for a minimum data set* (see Supplementary File 1). The anaesthetists were tasked with recruiting patients, obtaining their consent and recording the following information: date; patient number, age and weight; surgical procedure, whether emergency or elective; diagnosis; surgical wound classification† (see Supplementary File 2); time of surgical incision; duration of surgery; known allergies and recent prescription of antibiotics. The investigator subsequently reviewed the anaesthetic records and prescription charts to document information regarding SAP: whether administered or withheld (indication); choice (selection/antimicrobial spectrum) and dosages of drugs; time of injection; re-dosing (drug, dosage, time) and whether further antibiotics were prescribed for twenty-four hours or longer. Because awareness of observation might give rise to changing practice, the anaesthetists assisting with data gathering were not informed of the purpose of the study. At Groote Schuur Hospital, antibiotics are administered by the anaesthetists perioperatively. This is mostly done in conversation with the operating surgeon. Postoperative antibiotics are usually prescribed by the surgeons.

The data were evaluated by an intensivist and specialist medical microbiologist and compared to international and national SAP guidelines: SIGN,¹ South Australian expert Advisory Group on Antimicrobial Resistance (SAAGAR),⁶ American College of Surgeons and Surgical Infection Society: Surgical Site Infection Guidelines,² South African Society of Anaesthesiologists (SASA),⁵

National Health Laboratory Service Western Cape academic hospitals antimicrobial recommendations (NHLS);⁹ and the only (unpublished) local guideline made available, from the Groote Schuur Department of Urology. However, the SASA and NHLS recommendations lack detail, hence the inclusion of international guidelines.

According to the European Centre for Disease Control (ECDC), the defining aspects of SAP compliance are correct indication, selection, dosage, timing, and duration of antibiotic treatment.¹² Re-dosing was also included. These criteria were analysed as follows:

Indication

Administration of SAP was considered appropriate for clean-contaminated, contaminated and dirty surgeries or where surgical prostheses were implanted, and inappropriate for clean surgeries. Omission/withholding of SAP was considered appropriate for clean surgeries (that did not include surgical prosthetic implantation).

Selection

Spectrum of antimicrobial activity was evaluated by a microbiologist and intensivist from Groote Schuur Hospital in consideration of both their knowledge of local patterns of microbial sensitivity and recommendations from existing guidelines.

Dosage

Dosage: as prescribed by guidelines.^{1,6,8,9}

Table 1: Summary of SAP dosages considered correct

Drug	Dosage (Adult only)
Cefazolin	2 g (1 g acceptable if weight ≤ 80 kg)
Gentamycin	5–7 mg/kg
Metronidazole	500 mg
Clindamycin	600 mg
Amoxicillin/clavulanic acid	1.2 g

Timing

Timing of initial injection was considered correct if 15 to 60 minutes had elapsed prior to surgical incision or tourniquet insufflation for cefazolin, metronidazole, gentamycin, clindamycin, ampicillin and amoxicillin/clavulanic acid (fluoroquinolones and glycopeptides require infusion over one to two hours).⁸

Re-dosing

Re-dosing was considered appropriate if the duration of surgery exceeded two half-lives of the given antibiotic; or blood loss exceeded 1.5 l (in an adult). The time lag between the first and subsequent injections was considered correct if two half-lives had elapsed (four hours for cefazolin). The dose should be appropriate for weight or consistent with the initial dose in case of unknown or estimated weight.

Duration

Prolonged SAP for up to 24 hours was deemed correct for arthroplasty and orthopaedic implant surgery, and up to 48 hours for cardiac surgery. Allowances were made where complicated surgery, intraoperative spillage of bowel content or pre-existing infections necessitated antibiotic treatment beyond SAP.

Statistical analysis

Data were entered into a Microsoft excel database and analysed using Stata version 15 (Stata Corp). Since most of the variables were categorical, the Fisher's exact test was used to assess associations between the variables, disaggregated by whether SAP was withheld or given. For the continuous variables the comparison between those who received SAP and those who had it withheld, was via Mann-Whitney U test, as the variables were skewed. A *p*-value of < 0.05 was considered statistically significant.

Results

Over a one-week period, 194 patients were approached and 192 granted consent. Their anaesthetic records and prescription charts were reviewed, and these data were captured on data sheets. Of these, 180 were included for data analysis, as 12 sheets were unintelligible.

The median age of study participants was 44.5 years (IQR: 31.5–58), with a preponderance of females at 57.8%. The median estimated weight was 74 kg (IQR: 61–90).

Most patients presented for elective surgery (79.4%, 143/180) with the highest proportion of procedures coming from the orthopaedic department (20.6%, 37/180). The surgical characteristics are summarised in Table II.

Table II: Descriptive data for baseline surgical characteristics for the study sample (*n* = 180)

Characteristic	Total (<i>n</i> = 180)
Surgical department	<i>n</i> (%)
Cardiothoracic	13 (7.2)
Colorectal	6 (3.3)
ENT	16 (8.9)
General	14 (7.8)
Gynaecology	19 (10.6)
Head, neck and breast	7 (3.9)
Hepatobiliary	8 (4.4)
Maxillofacial	9 (5.0)
Neurology	4 (2.2)
Obstetrics	14 (7.8)
Ophthalmology	6 (3.3)
Orthopaedics	37 (20.6)
Renal	4 (2.2)
Trauma	1 (0.6)
Urology	13 (7.2)
Vascular	9 (5.0)
Wound classification, <i>n</i> (%)	
I	71 (39.4)
II	70 (38.9)
III	25 (13.9)
IV	14 (7.8)
Surgery	<i>n</i> (%)
Elective	143 (79.4)
Emergency	37 (20.6)
Duration of surgery, median (IQR)	75 (42–150)
Range (minutes)	5–435

A total of 28 patients had been receiving antibiotic treatment prior to presenting for surgery, as summarised in Table III.

Table III: Antibiotic treatment prior to surgery (*n* = 180)

Prior antibiotics	<i>n</i> (%)
None	152 (84.4)
Ofloxacin	1 (0.6)
Azithromycin and ceftriaxone	1 (0.6)
Cefazolin	2 (1.1)
Ceftriaxone	2 (1.1)
Ciprofloxacin and cefuroxime	1 (0.6)
Ciprofloxacin and metronidazole	1 (0.6)
Amoxicillin/clavulanic acid	14 (7.8)
Ertapenem and imipenem	1 (0.6)
Metronidazole	1 (0.6)
Nitrofurantoin	1 (0.6)
Amikan, piptaz and ciprofloxacin	2 (1.1)
Vancomycin and ceftriaxone	1 (0.6)

The various choices/combinations for SAP are illustrated in Table IV.

Table IV: SAP drug choice (*n* = 180)

Antibiotic prophylaxis	<i>n</i> (%)
Cefazolin	107 (59.4)
Cefazolin, gentamycin and metronidazole	3 (1.7)
Cefazolin and amoxicillin/clavulanic acid	1 (0.6)
Cefazolin and gentamycin	4 (2.2)
Cefazolin and metronidazole	12 (6.7)
Ceftriaxone	2 (1.1)
Chloromycetin (topical)	2 (1.1)
Clindamycin	2 (1.1)
Gentamycin	9 (5)
Metronidazole	3 (1.7)
Amoxicillin/clavulanic acid	4 (2.2)

In terms of the primary objectives:

Indication

SAP was appropriately administered or withheld in 161 cases (89.44%). Of the 149 patients who received SAP, it was appropriately administered in 137 cases (92%) and appropriately withheld in 24 of the 31 cases (77%). Consequently, SAP was incorrectly administered in 12 (clean) cases (12/180 = 6.67%) and incorrectly withheld in seven (7/180 = 3.89%). An appropriate antibiotic was selected in 121/156 cases (77.6%).

Dose

The dose was appropriate to weight in 110 of the 156 patients who required SAP (70.5%). There was consistent under-dosing of gentamycin.

Timing

Timing of initial injection was incorrect in 44.2% of the 156 participants that received SAP (*n* = 69), the time lag being too short (< 15 min) in 33 cases (21.2%); too long (> 60 min) in 13 (8.3%); unknown in nine (5.8%) and administered after surgical incision in seven cases (4.5%).

Regarding secondary objectives:

Re-dosing

Sixteen cases required a second dose of SAP, but it was administered to only 14. Of these 14, only three (21.4%) received an appropriate dose at an appropriate time. Under-dosing for weight occurred in six cases (42.9%), re-dosing too late in three (21.4%) and too early in two (14.3%). The second dose was incorrectly omitted in 2/16 cases (12.5%).

Duration

Antibiotics were prescribed for 24 hours in 57 cases (31.7%) but justified in only 41 (71.9%); and for 48 hours or more in 38 cases (21.1%). Extended duration was appropriate in 33 (86.8%) of these cases, as they were on antibiotic treatment for previously existing or suspected infection. SAP was inappropriately extended for 72 hours in two cardiac cases (5.3%) and 48 hours for two orthopaedic cases (5.3%) respectively. One obstetric patient received oral amoxicillin/clavulanic acid for one week, as this was thought to be warranted should the duration of a Caesarian section exceed one hour, but this practice is not supported by the literature. Maxillofacial cases were correctly prescribed an extended course of oral or topical antibiotic, as per the WHO recommendations.

These findings are summarised in Table V.

Table V: Rate of adherence in terms of antibiotic choice, dose, timing and re-dosing

Characteristic	Total (n = 180)
Appropriate prophylaxis choice	n (%)
Yes	121/156 (77.6)
No	35/156 (22.4)
Appropriate dose	
Yes	110/156 (70.5)
No	46/156 (29.5)
Appropriate timing	
Yes	87/156 (55.8)
No	69/156 (44.2)
Re-dose received	
Yes	14 (7.8)
Appropriate re-dose	
Yes	3/14 (21.4)
No	11/14 (78.6)
Antibiotic to incision time, median (IQR)	25 (15–35)
Range	-45–90

Discussion

Adherence to all the criteria of SAP compliance was achieved in 44.4% (n = 80). Breakdown by department is shown in Figure 1.

Erroneous omissions appear to be due to clinicians' assumption that previously prescribed antibiotics negate the need for SAP, regardless of the spectrum or half-life of those drugs. The reasons for incorrect timing may vary from logistical issues (many activities being performed at the same time around induction of anaesthesia and surgical incision) to lack of awareness of guidelines and inconsistencies in the available literature. While there is agreement in the literature that adequate tissue levels of the antibiotic must be attained prior to surgical incision or tourniquet insufflation, the ideal time lag has not been elucidated.¹ For example, the Belgian recommendation is 15 to 60 minutes,¹³ but the SIGN recommends 0 to 60 minutes,¹ and the WHO safety checklist reads, "antibiotic administered within 30 to 60 minutes prior to surgical incision". There is low quality evidence that administering SAP after surgical incision is harmful with a significantly increased risk of SSI, but due to the severity of morbidity associated with SSI, the recommendation against such a dosing strategy is strong.^{1,4}

The under-dosing of gentamycin may be due to anaesthetists being unfamiliar with the antibiotic, as it is prescribed less often and mostly for surgeries involving the urinary tract.

Concerning duration of SAP, there appears to be consensus amongst the sources quoted by the WHO that SAP should not exceed a single preoperative dose, with the possible exceptions of arthroplasty, open cardiac surgery and complicated maxillofacial surgery. The Royal College of Physicians of Ireland recommends prolonged SAP for up to 24 hours for open reduction and internal fixation of compound mandibular fractures, orthognathic surgery, complicated septorhinoplasty and head and neck surgery; and 24 to 48 hours for open cardiac surgery. According to the USA Institute for Health Care Improvement: surgical site infection, SAP must be discontinued within 24 hours or 48 hours for cardiac patients.⁴

Several international studies have been aimed at determining clinician adherence to existing SAP guidelines. A prospective investigation of three paediatric hospitals in Italy found that

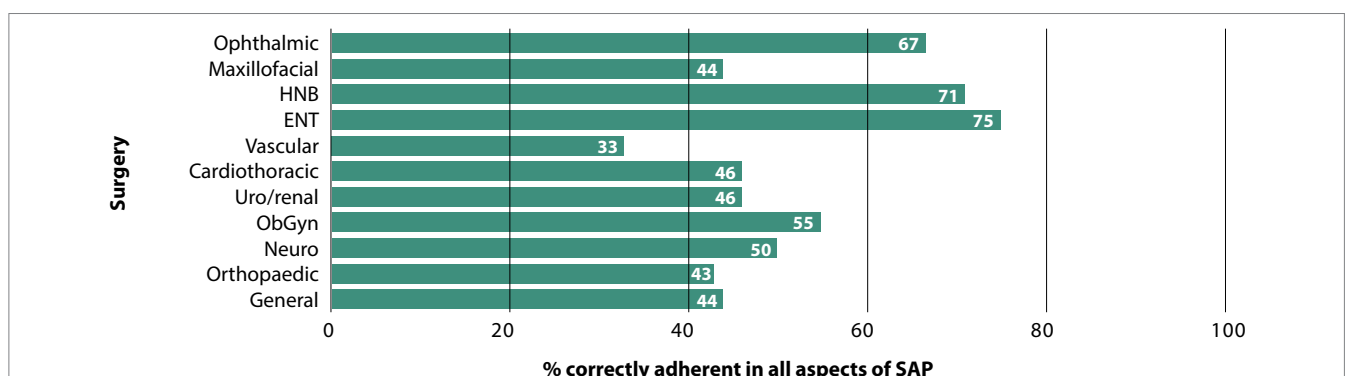


Figure 1: Percentage of cases where adherence to SAP guidelines was achieved in all aspects, by surgical department
HNB – head, neck, breast, ENT – ear, nose, throat, Uro – urology, OBGYN – obstetrics and gynaecology, General – colorectal-, hepatobiliary-, and upper gastrointestinal surgery

where SAP was indicated, exact adherence in terms of antibiotic choice, timing and duration was only 8%, with first dose timing and duration of prophylaxis being the biggest contributors to error. Under-use when SAP was indicated (81%) and over-use when not (18%) was also noted.¹⁴ A Brazilian review (2015) found that appropriate indications for antibiotic prophylaxis ranged from 70.3% to 95%; inappropriate indication from 2.3% to 100%; correct timing 12.7% to 100%; correct choice 22% to 95%; adequate discontinuation 5.8% to 91.4% and adequate antibiotic prophylaxis 0.3% to 84.5%.¹⁵

The awareness and knowledge of SAP guidelines have been shown to be lacking amongst anaesthetists at a tertiary hospital in South Africa.⁷ Globally, there is considerable variability in SAP compliance, with several studies demonstrating poor compliance.¹⁶ Such findings are reproduced in our study, with a non-compliance rate of 55.6% (p -value < 0.001). The most frequently observed errors included incorrect timing of first dose, issues with re-dosing and inconsistencies in prolonged continuation of SAP.

Limitations to this study include a small sample size, which prohibits generalisation and may impact on the reported results. For example, the impact of drug allergies on SAP compliance could not be elucidated, as none of the participants had a history of β -lactam allergy. Convenience sampling may also have led to selection bias. Furthermore, only some aspects of the data were directly observed and recorded by the anaesthetists, but to avoid the Hawthorne effect, information directly pertaining to the primary and secondary objectives was obtained from paper records in patient folders – which may have contained inaccurate information. The weight was known in only 83 (46.1%) and estimated in 97 (53.9%) cases. Wound classification may have been inaccurate, but this was addressed during a case by case re-evaluation of the data and should not have a significant effect on the analysis, as each procedure was carefully considered on its own merit.

The main strength of this study lies with its prospective nature, as opposed to the retrospective data analysis described in many of the larger studies. It appears to be the first audit of SAP practice undertaken in South Africa, and as such highlights many shortcomings in this arena.

Conclusion

In sub-Saharan Africa, cost constraints, staff shortages and limited facilities number among the challenges faced by clinicians, but a systematic review of interventions aimed at reducing the rate of SSI in this context postulates that improving the use of SAP may reduce the risk of SSI and help conserve scarce resources.¹⁷

Strategies aimed at improving compliance with SAP guidelines include implementing the use of personalised surgical antibiotic prophylaxis kits (SAPKs) at a university hospital in Nice;¹⁸ educating surgical staff by introducing an antimicrobial stewardship programme at acute care hospitals in Egypt;¹⁹ and incorporating standardised computerised order entries for

perioperative antibiotic prophylaxis at a university hospital in Philadelphia, USA.²⁰

Given the devastating consequences of SSI in terms of morbidity and mortality, measures to raise awareness and educate clinicians regarding SAP guidelines are warranted. We recommend that regular audits of SAP practice should be followed by studies of adherence and implementation fidelity.

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Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

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Supplementary files available online.