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RESEARCH

Anaesthetists' knowledge of surgical antibiotic prophylaxis: a prospective descriptive study

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Background: Surgical site infection (SSI) is the second most common hospital-acquired infection and results in increased morbidity and mortality and a longer hospital stay. Surgical antibiotic prophylaxis (SAP) is one component of broader strategies to reduce rates of SSI. Adherence to SAP guidelines is largely sub-optimal globally, with knowledge of appropriate SAP being an important factor that affects this. The study's objective was to describe awareness amongst anaesthetists at university-affiliated hospitals of available SAP guidelines and to describe their knowledge on the subject. Comparisons between senior and junior anaesthetists were to be made.
Methodology: A prospective descriptive study design using a self-administered questionnaire was employed. The study population was the anaesthetists in a university-affiliated Department of Anaesthesiology in Johannesburg, South Africa.
Results: The analysis included 135 completed questionnaires from the department's anaesthetists. A total of 15.6% of participants followed a specific guideline in their practice, 28% for senior anaesthetists vs. 4.2% for junior anaesthetists. The overall mean score for knowledge was 56.2%, 59.3% for senior anaesthetists vs. 53.6% for junior anaesthetists, which was statistically significant (*p*-value < 0.001). Overall knowledge was found to be poor and, specifically, knowledge regarding indication for prophylaxis, antibiotic re-dosing interval and duration of prophylaxis was poor.
Conclusion: The anaesthetists had poor knowledge regarding SAP. While the difference in knowledge between senior and junior anaesthetists was statistically significant, is it likely that this difference would not be substantial enough to have a clinical impact. The authors recommend interventions to improve the knowledge of the anaesthetists regarding SAP as well as the development of local SAP guidelines.

Keywords: anaesthetist, antibiotics, knowledge, perioperative, surgical prophylaxis, surgical site infection

Background

Surgical site infection (SSI) is the second most prevalent type of hospital-acquired infection (HAI).[1] Short-term consequences of SSI include a longer and more protracted hospital stay with associated increased costs. In certain types of surgery, for example, colonic surgery, SSI may also result in increased mortality.[2] Patients with SSI are 60% more likely to be admitted to ICU, five times more likely to be readmitted to hospital and are twice as likely to die.[3] The incidence of SSI is thus an important outcome measure of the quality of surgical care.[2] The importance of surgical antibiotic prophylaxis (SAP) is exemplified by its inclusion as one of the pre-incision checks in the WHO surgical safety checklist.[4]

SAP is one component of broader strategies to decrease SSI. The benefit of SAP relates to how effectively it prevents SSI and how severe the consequences of SSI are in each specific procedure.[2] SAP guidelines assess these factors and give recommendations on antibiotic prophylaxis for each procedure.

Certain important principles underpin the practice of SAP. To achieve effective prophylaxis, the antibiotics should have activity against the organisms that are likely to contaminate the site of surgery, they should be given in doses and at intervals sufficient to achieve satisfactory tissue concentrations during the procedure and should be administered for the shortest period possible in order to reduce adverse effects, cost and resistance.[5]

The existence of SAP guidelines is mostly to ensure optimal use of SAP to decrease the incidence of SSI. However, antibiotic stewardship also exists in order to minimise indiscriminate and injudicious use of antibiotics, which Gould[6] notes to be a causative factor in selecting and maintaining antibiotic-resistant bacteria. In spite of the existence of guidelines, adherence to antibiotic prescription guidelines is generally poor worldwide.[7]

In 1999, SAP was evaluated in a Brazilian academic hospital and it was found that only 3% of cases complied fully with the guidelines.[8] In the Netherlands, a multi-centre audit by Van Kasteren[9] in 2003 found that only 28% of cases adhered to all aspects of SAP protocols. In South Korea, a study by Choi *et al.*[10] in 2007 found compliance to be less than 1%. Similar studies examining SAP guideline compliance in Greece,[11] Abu Dhabi[12] and Australia[13] found rates of compliance to be 36%, 32% and 38% respectively. Notably, compliance with SAP has been found to be higher in the United States with a large multi-centre retrospective cohort study finding a compliance of 78%, largely attributed to the Surgical Care Improvement Project.[14]

The question of why doctors do not follow SAP guidelines was examined in a review by Gagliardi *et al.*[7] Their findings were that numerous factors interact to obstruct the provision of appropriate antibiotic administration. These include 'individual knowledge, attitude, beliefs and practice; team communication and allocation of responsibilities; and institutional support for promoting and monitoring antibiotic prophylaxis'.[7] Investigating the cause of poor SAP is thus complex and multi-faceted. Knowledge, however, is one important aspect of influence.

Studies assessing doctors' knowledge of SAP are limited. In 2015 Feuerstein *et al*.[15] assessed physicians' knowledge of prophylactic antibiotics in gastrointestinal endoscopic procedures. They found the median mark to be 70% which was deemed to be insufficient. A questionnaire distributed to orthopaedic surgeons indicated that only 30% knew the correct recommendations regarding SAP.[16] To the best of the authors' knowledge, there have been no studies to date assessing the knowledge of anaesthetists regarding appropriate SAP administration. However, a study assessing the knowledge of nurse anaesthetists in Nigeria found it to be inadequate.[17]

The primary objectives of the study were to describe awareness of anaesthetists of available SAP guidelines and to describe their knowledge regarding appropriate SAP. A secondary objective was to compare knowledge between senior and junior anaesthetists.

Methodology

A prospective descriptive research design was used. Ethics clearance was obtained from the Human Research Ethics Committee of the University of the Witwatersrand in Johannesburg, South Africa.

The study population was anaesthetists working in the Department of Anaesthesiology at the University of the Witwatersrand (Wits) in Johannesburg, South Africa. The department consists of 21 junior medical officers (non-specialists), 112 registrars (specialists-in-training) and 76 consultant anaesthetists. Their scope of practice is across five academic hospitals in Johannesburg. Convenience sampling was used and a sample size of more than 60% of the department's anaesthetists was targeted.[18]

A knowledge-based questionnaire was developed by the authors, based on the literature available on the topic, thereby ensuring content validity. Face validity of the questionnaire was obtained by consulting with a specialist medical microbiologist and two senior anaesthesiologists, including one who is an expert in pharmacology.

The questionnaire included demographic information and questions regarding awareness of SAP guidelines. Following this, knowledge of five key principles of appropriate SAP was tested, namely: timing of the first dose of SAP; re-dosing intervals; duration of prophylaxis; antimicrobial spectrum required for specific procedures; and whether prophylaxis is indicated or not. The structure of these five areas was as follows:

> Timing of first dose: One question asking the correct timeframe in relation to skin incision in which the first dose of prophylaxis must be administered. Two further questions asking which antibiotics are exceptions to this rule and within what time frame they should be administered.
>
> Duration of prophylaxis: A single open-ended question on the optimal duration of prophylaxis in most surgical procedures.
>
> Re-dosing interval: A table with six antibiotics in which participants had to state the re-dosing interval for each, should it be required.
>
> Antimicrobial spectrum: A table with five different procedures listed. Participants had to tick one or more of three boxes corresponding to Gram-positive bacteria, Gram-negative bacteria and anaerobes according to what spectrum of antimicrobial coverage they thought was required for the procedure. The range of procedures included incision though the skin as well as various other body viscera: upper gastrointestinal, colonic, gynaecological, urological and respiratory tract.
>
> Indication for prophylaxis: Participants had to tick one of two boxes (yes or no) regarding whether they thought prophylaxis was indicated for 16 different procedures.

The questionnaire was handed out to anaesthetists at weekly departmental academic meetings over a two-month period. Participation was voluntary and anonymity was maintained.

At the time of the study, there were no local guidelines at the university-affiliated hospitals in Johannesburg with the exception of one of the smaller hospitals, which had produced an unpublished guideline.[19] In the absence of ubiquitous local guidelines, the memorandum by which the questionnaire was marked was based on a collation of three prominent international guidelines and two South African guidelines, namely: the Scottish Intercollegiate Guideline Network (SIGN) – Antibiotic Prophylaxis in Surgery;[2] the South Australia Expert Advisory Group on Antimicrobial Resistance (SAAGAR) – Surgical Antibiotic Prophylaxis Guideline;[20] the American Society of Health-systems Pharmacists (ASHP) – Clinical practice guidelines for antimicrobial prophylaxis in surgery;[5] the Wits Donald Gordon Medical Centre (WDGMC) – Antibiotic Surgical Prophylaxis Guideline;[19] and the South African Antibiotic Stewardship Programme (SAASP) – A pocket guide to antibiotic prescribing for adults in South Africa.[21]

Data were analysed using GraphPad InStat version 3.1 (www.graphpad.com) and Microsoft Excel® 2010 (Microsoft Corp, Redmond, WA, USA). Continuous variables were described using means and standard deviations for normally distributed data and medians and interquartile ranges for non-normally distributed data. Comparisons were done using *t*-tests for parametric data or Mann–Whitney U-test, Fisher's exact test and chi-squared tests for non-parametric data. Categorical data were represented as numbers and percentages. Distribution of data was assessed for normality using the Kolmogorov–Smirnov test. A p-value of ≤ 0.05 was considered statistically significant.

Results

A total of 160 questionnaires were handed out, of which 139 (86.9%) were returned. Four questionnaires were excluded as they were returned blank. Therefore 135 questionnaires were included in the study ($n = 135$), equating to a response rate of 84.4% and a sample size of 66.6% of the department.

Table 1 represents the demographics of the participants in the study. Junior anaesthetists were defined as medical officers or registrars in years one to three of training. Senior anaesthetists were defined as consultants and registrars in their fourth year of training.

Of the total participants, only 27 (20%) could name an existing SAP guideline. Furthermore only 21 (15.6%) participants followed a guideline in their practice. Broken down into junior

Table 1: Demographics of participants

Demographics	Number (*n*)	Percentage (%)
Gender:		
Male	44	32.6
Female	91	67.4
Professional designation:		
Medical officer	27	20.0
1st year registrar	14	10.4
2nd year registrar	13	9.6
3rd year registrar	17	12.6
4th year registrar	24	17.8
Consultant	40	29.6
Seniority:		
Junior anaesthetist	71	52.6
Senior anaesthetist	64	47.4
Experience in anaesthesia:		
≥ 5 years	80	59.3
< 5 years	55	40.7

and senior anaesthetists, 3 (4.2%) and 18 (28.1%) participants respectively followed a guideline (*p*-value 0.0002 using Fisher's exact test). The most commonly used guideline was the South African Society of Anaesthetists' (SASA) guideline, stated by 7 (5.2%) participants, followed by the National Institute of Clinical Excellence (NICE) guidelines, stated by 2 (1.5%) participants. A further 12 different guidelines were each stated once.

Tables 2 and 3 summarise the results of the knowledge of the participants. Table 2 represents the overall score of the participants and the sections in which there were multiple questions. Table 3 represents the results of the sections with a single question in each. *P*-values are stated for comparison between senior and junior anaesthetists.

Pertaining to the results on re-dosing interval, the percentage of participants who answered correctly for each individual antibiotic is represented in Figure 1. The *p*-values for comparison between senior and junior anaesthetists for each antibiotic were all statistically insignificant.

Breaking down the results of the section on whether prophylaxis is indicated or not, Figure 2 shows the percentage of total participants who correctly answered whether or not prophylaxis was required for each procedure.

Discussion

The results of the questionnaire indicate that the knowledge amongst the anaesthetists regarding SAP is poor, with the mean score for the questionnaire being 56.2%. To the best of the authors' knowledge, no study quantifying the knowledge of doctor anaesthetists regarding SAP has previously been done. However, a number of studies allude to doctors having poor knowledge about antibiotics.[15,16,22] Algabe-Briggs *et al.*[23] surveyed anaesthetists about how they perceived their own knowledge regarding SAP and found that 75% thought their training in antibiotic selection and administration was inadequate.

Senior anaesthetists scored slightly higher than junior anaesthetists (59.3% vs. 53.6%), the difference being statistically significant. However, the authors feel that this difference in knowledge (5.6%) would not be enough to translate into a difference in clinical outcome. This result is also not entirely surprising. Lucet *et al.*[24] surveyed the knowledge of doctors relating to antibiotic prescribing in general. They found that knowledge did not differ significantly between senior and junior doctors.

Awareness of available SAP guidelines was particularly poor, with few anaesthetists following any guideline. The NICE guidelines and the SASA guidelines, the two most commonly followed guidelines, were not included in the marking memorandum of the questionnaire since they are very brief documents with insufficient detail. The lack of widely available local guidelines at the university-affiliated hospitals possibly plays a role in

Table 2: Knowledge of participants

Knowledge	Score (%) Mean (SD) or Median (IQR)
Overall score:	
All participants	56.2 (8.2)
Senior anaesthetists	59.3 (7.6)
Junior anaesthetists	53.6 (8.0)
p-value	< 0.0001 (*t*-test)
Re-dosing interval:	
All participants	40 (20–60)
Senior anaesthetists	40 (20–60)
Junior anaesthetists	20 (20–40)
p-value	0.071 (Mann–Whitney U-test)
Spectrum of cover:	
All participants	80 (66.7–93.3)
Senior anaesthetists	83.3 (71.7–88.3)
Junior anaesthetists	80.0 (60.0–93.3)
p-value	0.39 (Mann–Whitney U-test)
Indication for prophylaxis:	
All participants	65.0 (11.9)
Senior anaesthetists	68.8 (11.0)
Junior anaesthetists	61.9 (11.4)
p-value	0.0005 (*t*-test)

Table 3: Knowledge of participants

Knowledge	Participants answering correctly *n* (%)
Timing of first dose:	
All participants	128 (95.6)
Senior anaesthetists	61 (95.3)
Junior anaesthetists	68 (95.7)
p-value	1.0 (Fisher's exact test)
Timing exception (vancomycin):	
All participants	23 (17.0)
Senior anaesthetists	14 (21.9)
Junior anaesthetists	9 (12.7)
p-value	0.17 (chi-squared test)
Timing exception (fluoroquinolones):	
All participants	0 (0)
Senior anaesthetists	0 (0)
Junior anaesthetists	0 (0)
Duration of prophylaxis:	
All participants	49 (36.3)
Senior anaesthetists	32 (50.0)
Junior anaesthetists	17 (23.9)
p-value	0.0017 (chi-squared test)

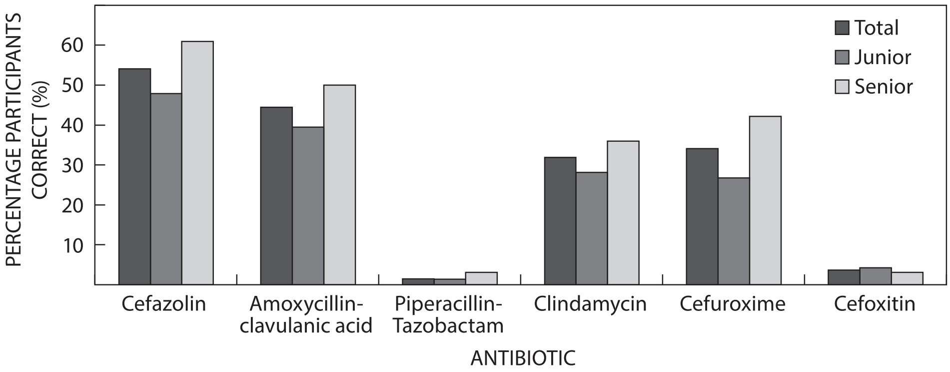

Figure 1: Percentage of participants answering correctly: re-dosing interval for each antibiotic.

anaesthetists not being knowledgeable about SAP, since the availability of a guideline would be expected to bring the subject to their attention. A surprising result is that the large difference among senior versus junior anaesthetists who follow a guideline has not translated into a large difference in knowledge. Possible explanations are that the absolute number of these participants is small relative to the sample size and that the guidelines they followed were not sufficiently detailed.

The knowledge of the anaesthetists varied considerably across the five principles of SAP that were examined. Knowledge was lacking in certain aspects and to varying degrees.

The median mark for the section on re-dosing interval was 40.0% for all participants. Junior anaesthetists scored significantly lower than their senior peers. The two antibiotics for which the highest number of participants correctly knew the re-dosing interval were cefazolin (54.4%) and amoxicillin-clavulanic acid (44.4%). This is likely explained by the fact that these two antibiotics are amongst the most commonly used antibiotics for SAP at the university-affiliated hospitals. The poorer scores for clindamycin, cefuroxime, cefoxitin and piperacillin-tazobactam may partly be explained by their infrequent use and availability for SAP at these hospitals.

In the absence of widely available local guidelines against which to mark participants' choice of antibiotic, judging the correctness of a specific antibiotic was deemed to be difficult and not fully objective, since some antibiotic choices for a certain procedure may not be considered first line for prophylaxis but also may not be entirely incorrect in their spectrum of coverage. As a surrogate, we tested the participants' understanding of the spectrum of antimicrobial cover required.

The median score of all participants in this section was 80.0%, with no statistically significant difference between junior and senior anaesthetists. In a survey of antibiotic choice at a tertiary academic hospital, Gentile *et al*.[25] showed that 68% of doctors used incorrect criteria in selecting antibiotic choice. In contrast Van Kasteren *et al*.[9] showed that 92% of doctors in Dutch hospitals selected the correct antibiotic. However, in those hospitals, local guidelines were available and endorsed.

The mean score for the section on whether prophylaxis is indicated for specific procedures was 65.0%. Senior anaesthetists had higher scores than junior anaesthetists, which was statistically significant. It must be kept in mind that due to the yes/no nature of this section, participants had a 50% chance of getting each question correct even with no knowledge. Our conclusion is therefore that this result is poor.

The procedures for which the fewest number of participants answered correctly were all procedures in which prophylaxis is not indicated. This implies that the participants are over-prescribing antibiotic prophylaxis, with the unnecessary risk of adverse reactions, increased costs and possibly increasing the risk of bacterial resistance. In all eight procedures in which

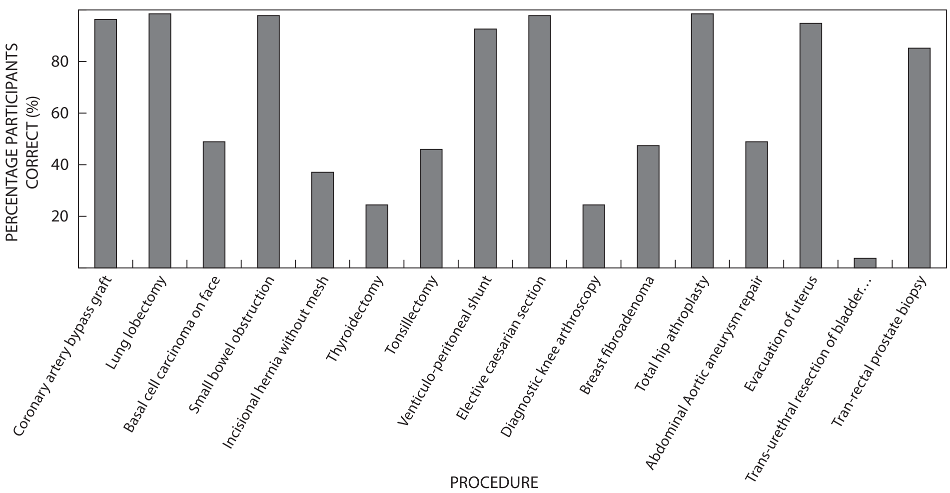

Figure 2: Percentage of participants correctly answering whether prophylaxis is indicated or not for each procedure.

prophylaxis was indicated, the number of participants who scored correctly was in excess of 80.0%. The greater problem thus appears to be over-prescription of SAP, rather than inappropriate omission of SAP.

This finding is in keeping with the academic literature. In their critical appraisal of the literature in 2007, Tourmousoglou *et al.*[11] noted that 19% of patients inappropriately received SAP when it was not indicated. In data extracted from the CareTrack Australia study, Hooper *et al.*[13] found that 72% of patients who did not need prophylaxis received antibiotics unnecessarily.

A total of 95.6% of participants knew that SAP had to be administered within an hour of skin incision, with results between junior and senior anaesthetists not being significantly different. The prospective study by Tourmousoglu *et al.*[11] showed that 100% of patients received their dose of prophylaxis on time. In contrast, the audit by Van Kasterens *et al.*[9] showed that the timing of the first dose of prophylaxis was correct in only 50% of cases. A review by El Hassan *et al.*[12] in Abu Dhabi showed that the timing of administration was incorrect in 69.3% of cases. These latter two studies, however, audited practice and it must be noted that there are factors other than knowledge that affect practice.

Only 17.0% of participants knew that vancomycin was an exception to the guideline of administering SAP within an hour of incision since it is required to be given as an infusion over one to two hours. Of these few participants, only 43.5% knew the correct timing. No participants identified the fluoroquinolones as an exception to the rule. One possible explanation is that these drugs are rarely used and are not freely available in the university-affiliated hospitals.

Most guidelines state that prophylaxis should be continued only for the duration of the surgery, with a few exceptions such as cardiac surgery and possibly arthroplasty surgery.[2] Only 36.3% of participants knew this. Significantly fewer junior anaesthetists (23.9%) answered this question correctly compared with senior anaesthetists (50.0%).

A large proportion of the participants felt that prophylaxis should be continued beyond the duration of the surgery and beyond 24 hours. It would appear that unnecessary extra dosing postoperatively is a problem in SAP in the university-affiliated hospitals. This carries the problems relating to unnecessary dosing described earlier. In the review by Hassan *et al.*[12] 59.7% of patients received SAP for longer than 24 hours, while in a study by Rafati *et al.*[26] in an Iranian hospital the figure was 40.2%.

The incidence of SSI differs significantly across surgical disciplines.[27] De Lissovoy *et al.*[28] calculated the incidence of SSI to be 20% of the total number of a projected 1.7 million HAIs in the USA every year. They estimated a burden of an additional one million hospital-days at a cost of close to $1.6 billion annually as a result of SSI. The authors also note that the treatment of SSI frequently requires antibiotic treatment, which may contribute to driving antibiotic resistance. Furthermore, the increased hospital stay puts patients at risk of other complications such as pressure ulcers or further HAIs from the use of urinary catheters and bloodstream catheters.[28] SIGN quotes a United Kingdom study showing that SSI results in an average of 6.5 extra days of hospital admission.[2]

The lack of widely available local guidelines has hindered our ability to construct sections of the questionnaire regarding the participants' choice of specific antibiotics for prophylaxis.

Many of the questions in the questionnaire were yes/no answers with a 50% chance of choosing the correct answer, or involved ticking the correct boxes. The results of these questions may possibly be influenced by guesswork. There is also a possibility of data contamination since participants were targeted over a period of time.

Since convenience sampling was used in our study it was not possible to survey the entire department, which could be a source of bias. This study is also based in a single university-affiliated department, which may limit extrapolation to other centres in South Africa or overseas where there are established guidelines.

Conclusions

The anaesthetists showed poor overall knowledge of SAP and inadequate awareness of SAP guidelines. There were unsatisfactory scores regarding indication for prophylaxis, duration of prophylaxis and re-dosing interval. Knowledge of correct timing of prophylaxis was found to be good, while the data on spectrum of bacterial cover appear to indicate acceptable knowledge. While senior anaesthetists achieved higher scores overall than junior anaesthetists, the difference in knowledge appears likely to be insufficient to have a clinical impact on providing good SAP. The authors recommend that SAP receive greater attention in the training curriculum of registrars. Local anaesthesia journals and continuing medical educations programmes could focus on the topic of SAP as a means of improving senior anaesthetists' knowledge as well. Other interventions that have proved successful worldwide include auditing SAP received by patients and notifying providers of their errors,[29] distributing newsletters,[30] use of a timeout period in which SAP can be administered[30] and development and implementation of public reporting of compliance with SAP guidelines.[14]

The lack of widely available local guidelines at the university-affiliated hospitals in which the study population works may contribute to the lack of knowledge and poor awareness of guidelines. We further recommend that a multidisciplinary team of clinical, nursing, administrative and management stakeholders at these hospitals set about compiling guidelines for SAP as an initial step towards improving the provision of appropriate SAP and decreasing SSI.

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