REVIEW ARTICLE

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The Surgical antimicrobial prophylaxis; an Irish experience

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ABSTRACT

The inappropriate and excessive use of antibiotics for surgical antimicrobial prophylaxis (SAP) leads to increases in hospital costs, bacterial resistance and adverse effects. This paper outlines the appropriateness of agent used, dose given, duration and documentation of SAP and suggests ways to improve future practice.

Key words: surgical antimicrobial prophylaxis (SAP), surgical site infection (SSI).

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Introduction

Surgical site infections (SSI) are the most common nosocomial infection in patients undergoing surgery; they remain a major source of postoperative morbidity and a major cause of healthcare acquired infection.[1-4] In a recent natural point prevalence survey in Ireland, SSI was identified as the most prevalent healthcare associate infection.[1]

The principles of surgical antimicrobial prophylaxis (SAP) have been defined over years: administration of prophylaxis just prior to surgery, maintenance of sufficient tissue drug levels for the duration of the procedure and for no longer than 24 hours, and the given antimicrobial agent is active against those organisms most likely to be encountered in the particular surgical fields.[5,6] The Scottish Intercollegiate Guideline Network (SIGN) guideline "Antibiotic Prophylaxis in Surgery" was published in July 2000 and republished in July 2008 to provide evidence for current practice pertaining to antibiotic use. This guideline was chosen to provide a framework for audit as it is well referenced; however, a care handle for the prevention of SSI has recently been produced by the joint RCPI/RCSI working group on prevention of SSI.[1]

The goal of SAP is to reduce rates of surgical site and healthcare-associated infections and as a consequence to reduce surgical morbidity and mortality in a manner that is supported by evidence of effectiveness, to minimize the effect of antimicrobial on the patient's normal bacterial flora, to minimize adverse effects and to cause minimal change to the patient's host defenses.[2,6]

In general, a single therapeutic dose of suitable antibiotic, administered intravenously at induction of anaesthesia, helps to prevent SSI by inhibiting growth of contaminating bacteria. However, the inappropriate and excessive use of antibiotics for SAP leads to increases in hospital costs, ineffectiveness, and/or a decline in susceptibility of bacteria. Even a single dose of antibiotic increases the risk of *Clostridia difficile* infection.[7] The finding of pus or a perforated viscus at surgery implies that infection was present before surgery and warrants a course of treatment, not prophylaxis.

The choice of agent will be governed by the surgical procedure and the likely potential pathogens. Clinicians should also take into account

Table 1. Classification of surgical procedures

Clean	Clean Contaminated	Contaminated
• No breach of respiratory, alimentary or genito urinary tracts • Non-traumatic • No inflammation • No break in technique	• Non-traumatic but break in technique or breach of respiratory, alimentary or genito-urinary tract • No significant spillage	• Major break in technique • Gross spillage from a viscus that may include purulent material • Dirty traumatic wounds, faecal contamination, foreign body, de vitalised viscus • Pus encountered from any source during surgery
↓	↓	↓
No Prophylaxis Unless insertion of device or prosthesis	Prophylaxis for <24 hours Usually single dose	Treatment course may be required for 5-7 days

adverse effect profile and patient drug allergies. The guidelines apply to patients admitted from the community for clean, clean-contaminated and contaminated surgical procedures. If the patient has been in hospital or has a history of methicillin-resistant *Staphylococcus aureus* (MRSA) colonisation, SAP may needs adjustment.[8] The duration of antimicrobial surgical prophylaxis should be a SINGLE dose, except in certain circumstances. An agent that may be appropriate for surgical prophylaxis may not be the optimal agent for the treatment of an established infection. Therefore, the continuation of an agent that was initially used for prophylaxis may represent suboptimal therapy. If concerned, or if the patient is allergic to one of the recommended agents, seek specialist advice (Microbiologist).

Timing and duration of prophylaxis

The aim of prophylaxis is to have maximum tissue antibiotic levels at the time of first incision. For this reason, prophylaxis is administered at induction of anaesthesia (≥30 to ≤60 minutes) before skin incision.[9] The duration of surgical prophylaxis should be a single dose,[10] except:

A. Blood loss – fluid replacement: Serum anti-

Table 2: Prevention of infection in UROLOGICAL procedures

Procedure	Regimen	Number and timing of doses
Transrectal prostate biopsy	*GENTAMICIN* 3-5 mg/kg IV ***plus*** *METRONIDAZOLE* 500 mg IV as single doses	1 dose at induction
Transurethral resection of the prostate	*GENTAMICIN* 3 mg/kg IV as a single dose ***plus*** *AMOXICILLIN* 1 g **Penicillin allergy:** *GENTAMICIN* 3 mg/kg IV	1 dose at induction
Transurethral resection of bladder tumours	ANTIMICROBIAL PROPHYLAXIS IS **NOT** RECOMMENDED UNLESS POSITIVE MSU	
Nephrectomy	*CO-AMOXICLAV* 1.2 g IV **Penicillin allergy:** *GENTAMICIN* 3 mg/kg ***plus*** *METRONIDAZOLE* 500 mg IV	1 dose at induction
Shock wave lithotripsy	*GENTAMICIN* 3 mg/kg IV	1 dose at induction
Endoscopic ureteric stone fragmentation/removal	*GENTAMICIN* 3 mg/kg IV	1 dose at induction
Percutaneous nephrolithotomy Antibiotic prophylaxis is recommended with stone > 20 mm or with pelvicalyceal dilation	*CIPROFLOXACIN* 500 mg PO bd for one week pre-operatively	1 week Preoperative

Table 3: Prevention of infection in GASTROINTESTINAL surgery

Procedure	Regimen	Number and timing of doses
• Upper GI (stomach or oesophagus) • Gall bladder surgery (open) • Gall bladder surgery (laparoscopic) - Antibiotic prophylaxis is ***NOT*** recommended unless high risk patient • Lower GI (colon, rectum, appendix) • ERCP/PEG - Antibiotic prophylaxis is ***NOT*** recommended unless high risk patient • Hernia repair - Antibiotic prophylaxis is ***NOT*** recommended unless mesh involvement	*CO-AMOXICLAV* 1.2 g IV **Penicillin allergy:** *GENTAMICIN* 3-5 mg/kg ***plus*** *METRONIDAZOLE* 500 mg IV **MRSA risk or history:** *Vancomycin* 15 mg/kg (max 2 g) ***plus*** *Gentamycin* 3-5 mg/kg ***plus*** *Metronidazole* 500 mg IV	*One dose at induction*
• Splenectomy	Antimicrobial prophylaxis is ***not*** recommended unless immunosuppression. See advice on perioperative vaccination and post-splenectomy antibiotic prophylaxis	

biotic concentrations are reduced by blood loss and fluid replacement, especially during the first hour of surgery when antibiotic levels are high. In the event of major intra-operative blood loss (>1.5 litres) additional doses of prophylactic antibiotic should be considered after fluid replacement.

B. Prolonged surgical procedures: Many antibiotics, such as cephalosporins (e.g. cefuroxime) are short acting and therefore an additional dose should be administered during the surgery if the procedure lasts longer than 4 hours.

Classification of surgical procedures

Surgery may be classified as clean, clean contaminated or contaminated (Table 1). No prophylaxis is necessary for clean surgery (unless insertion of device or prosthesis). One dose of antibiotics is usually adequate for clean-contaminated surgery or insertion of a medical device/prosthesis. There is certainly no benefit in prolonging antibiotics beyond 24 hours, after which antibiotic-associated risks (e.g., *Clostridia difficile* infection,[7] drug toxicity) increase. For contaminated surgery, a 5-7 days treatment course may be required. The continuation of prophylaxis until all drains and catheters have been removed is not appropriate.

Appropriateness of SAP

Appropriateness of SAP is determined using the local health surgical antimicrobial prophylaxis guidelines. These guidelines provide a broad outline of procedures where prophylaxis is recommended and those where prophylaxis

Table 4: Prevention of infection in VASCULAR surgery

Procedure	Regimen	Number and timing of doses
• VARICOSE VEINS BRACHIAL OR PROSTHETIC PROCEDURES (not involving prosthetic material)·	ANTIBIOTIC PROPHYLAXIS IS ***NOT*** RECOMMENDED	
• Amputation • Aortic aneurysm repair • Prevention of gas gangrene in high lower limb amputation or following major trauma (penetrating abdominal injuries may require continuation of therapy) • Vascular surgery (bypass or amputation) a) elective procedures MRSA screen patient pre-operation - MRSA-negative - MRSA colonised - Penicillin allergy b) procedures that are carried out as emergencies and/or on patients who have not been screened	*CO-AMOXICLAV* 1.2 g IV *VANCOMYCIN 15 mg/kg IV* ***plus*** *GENTAMICIN 3 mg/kg IV* ***plus*** *METRONIDAZOLE 500 mg IV*	*One dose at induction*

Table 5: Prevention of infection in BREAST and THORACIC Surgery

Procedure	Regimen	Number and timing of doses
• Breast reconstruction with implant • Breast cancer surgery • Breast reshaping procedures	FLUCLOXACILLIN 1 g IV **Penicillin allergy:** CLINDAMYCIN 600 mg IV MRSA risk - VANCOMYCIN 15 mg/kg IV	*One dose at induction*
• Implantable cardiac device (ICD)/pacemaker insertion • Screen patients for MRSA at least 5 days before surgery according to MRSA guidelines - MRSA-negative	*FLUCLOXACILLIN 1 g IV at induction*	*1 dose at Induction AND give two further doses – 6 hours apart*
- MRSA colonised	*VANCOMYCIN* 15 mg/kg (max 2 g) IV (Further antibiotic prophylaxis is ***NOT*** required due to extended duration of action)	
• Pulmonary resection	CO-AMOXICLAV 1.2 g IV **Penicillin allergy**: CLINDAMYCIN 600 mg	*One dose at induction*

Table 6: Prevention of infection in TRAUMA and ORTHOPAEDIC Surgery

Procedure	Regimen	Number and timing of doses
• Arthroscopy • Orthopaedic surgery without an implant	ANTIMICROBIAL PROPHYLAXIS IS NOT RECOMMENDED	
• Minor metalwork insertion (e.g. K-wire, screws, small orthopaedic plates)		One dose at induction
• Elective major procedures involving metalwork, including joint, pelvic or spinal implants Screen patients for MRSA before surgery according to MRSA guidelines - MRSA-negative	*CEFUROXIME* 1.5 g IV Antibiotic loaded cement is recommended for cemented joint replacements in addition to intravenous antibiotics	1 dose at Induction; give two further doses – 8 hours apart
- MRSA colonised - Penicillin allergy		
• Major procedures involving metalwork including joint, pelvic or spinal implants carried out as emergencies and/or on patients who have not been screened.	*VANCOMYCIN* 15 mg/kg (max 2 g) IV	One dose at induction
• Compound fracture intervention • (+/- insertion of a screw/nail)	CEFUROXIME 1.5 g IV ***plus*** METRONIDAZOLE 500 mg IV **Penicillin allergy** (anaphylaxis) – GENTAMICIN 3 mg/kg ***plus*** METRONIDAZOLE 500 mg IV	Duration should be no longer than 24 hours

is considered unnecessary.[11] (Tables 2-8)

Recommendations and Discussion

Postoperative infection at surgical sites is one of the most common nosocomial infections among hospitalized surgical patients.[12] SAP has shown to be effective for many procedures, and is particularly indicated for operations that

Table 7: Prevention of infection in GYNAECOLOGICAL surgery:

Procedure	Regimen	Number and timing of doses
• Abdominal Hysterectomy • Vaginal hysterectomy • Vaginal operations and repairs • Surgery that may involve the bowel • Urodynamic testing (if positive results for bacteriuria or UTI)	CO-AMOXICLAV 1.2 g IV **Penicillin allergy:** GENTAMICIN 3 mg/kg ***plus*** METRONIDAZOLE 500 mg IV	One dose at induction
• Post operative and temporary indwelling catheters (manage with strict maintenance and early withdrawal of urinary catheter) • Diagnostic laparoscopy • Hysterosalpingography (HSG) (If HSG demonstrates dilated fallopian tubes, history of PID, antibiotic prophylaxis should be given as above) • Hysteroscopy surgery • Exploratory laparotomy	ANTIBIOTIC PROPHYLAXIS NOT RECOMMENDED	

Table 8: Prevention of infection in EAR, NOSE, THROAT and ENDOCRINE Surgery (Most procedures do not require prophylaxis)

Procedure	Regimen	Number and timing of doses
• Ear surgery (clean /clean-contaminated) • Tonsillectomy • Adenoidectomy • Routine nose, sinus and endoscopic sinus surgery • Thyroid, parathyroid surgery	ANTIMICROBIAL PROPHYLAXIS IS ***NOT*** RECOMMENDED. However, where the patient is debilitated, if surgery is likely to be complex or the patient has a malignancy, prophylaxis may be indicated	
• Cochlear implant • Above procedures where the patient is debilitated, if surgery is likely to be complex or the patient has a malignancy, prophylaxis may be indicated	*CO-AMOXICLAV* 1.2 g IV **Penicillin allergy**: *GENTAMICIN* 3 mg/kg ***plus*** *METRONIDAZOLE* 500 mg IV	One dose at induction
• Complex septorhinoplasty	CO-AMOXICLAV 1.2 g IV **Penicillin allergy:** *ERYTHROMYCIN* 1 g IV	**Duration should be no longer than 24 hours**
• Grommet insertion	*OFLOXACIN* 0.3 % drops topically	1 dose post-operatively

carry a high risk of infection, and for patients in whom such an infection would be likely to cause severe morbidity or death.[6]

In general, a single therapeutic dose of suitable antibiotics, administered intravenously at induction of anaesthesia, helps to prevent SSI after many surgical procedures.[13] SAP is widely used during performance of surgical procedures. Most regimens selected, are largely in accordance with the vast array of published guidelines in the area of surgical prophylaxis. Prophylaxis should be used appropriately in the majority of cases. As enough guidelines exist and have been agreed with surgical groups, alternative agents, although still appropriate are used. However, this may result in confusion among medical staff and should be avoided. In event that alternative agent is used, the reason should be documented but ideally agreed guideline should be tolerated.

The timing of administration is crucial; SAP should be administered at induction of anaesthesia (i.e. ≥30 to ≤60 minutes before skin incision) to be optimally effective, although documentation needs to be optimal.[14,15] As recent recommendation concedes, SAP should be prescribed and documented in an agreed format on the drug chart. This should reduce the risk of error and inappropriate used. Where appropriate, it should be documented prior to the patient going to theatre. Timing of administration must be optimized in theatre and appropriate process including audit should be used to facilitate this (by RCSI documentation). At the same time, appropriate documentation is essential if this is to be improved. Every surgical ward and operative theatre should have guidelines for prophylaxis, taking into account the efficacy, safety and cost of the available antimicrobial regimens, the likely microorganisms encountered during a given procedure, the hospital environment and the pattern of common postoperative infections.

Check allergy status; patients with rash (non-urticarial) to penicillin may receive cephalosporins (e.g. cefuroxime). Patients exhibit severe penicillin allergy (e.g. angioedema or anaphylaxis), must avoid all beta-lactam antibiotics. For prolonged operative procedures (>4 hours) and/or major blood loss, additional intra-oper-

Table 9: Vancomycin Dosing and Infusion Time

Vancomycin Dosing and Infusion Time (Note maximum rate of infusion = 10 mg/ minute (600 mg/ hour))			
Patient's Weight	**Dose**	**Infusion Time & Volume**	**Ideally commence infusion**
42 – 58 kg	750 mg	75 minutes in 250 ml NS	85 – 105 min prior to skin incision
59 – 74 kg	1000 mg	100 minutes in 250 ml NS	110 – 130 min prior to skin incision
75 – 91 kg	1250 mg	125 minutes in 250 ml NS	135 – 155 min prior to skin incision
92 – 108 kg	1500 mg	150 minutes in 250 ml NS	160 – 180 min prior to skin incision
109 – 124 kg	1750 mg	175 minutes in 500 ml NS	185 – 205 min prior to skin incision
≥ 125 kg	2000 mg	200 minutes in 500 ml NS	210 – 230 min prior to skin incision

ative doses should be administered, give gentamycin 5 mg/kg at induction (maximum gentamicin dose is 500 mg) and an additional dose of 2 mg/kg. All antibiotic doses are for adults with normal renal function. Reduce gentamicin dose to 2 mg/kg IV if Creatinine Clearance (Cr. C) is <30 ml/min. Clindamycin should be administered in theatre and the dose of 600 mg should be infused in 50 ml normal saline (NS) or glucose 5% (G5) over 20 minutes. Vancomycin should be administered in the ward (see Table 9) to aid in the calculation of vancomycin infusion start time, and ward and theatre nursing staff should liaise regarding procedure start time. Clarithromycin can cause significant increases in international normalized ratio of warfarin (INR) for patients on warfarin and clarithromycin; INR must be monitored very closely and appropriate warfarin dose adjustments made as necessary.

Urology Patients with laboratory confirmed urinary infection should be treated with the appropriate agent based on susceptibility results. Pre-operative urine culture will guide the choice of agent if the urine is culture positive. If the susceptibility results are not available or unknown, SAP should be use (see Table 2).

In gastroenterology surgery, antibiotic prophylaxis should be considered for high-risk patients such as intraoperative cholangiogram, pancreatic pseudo-cyst, immunosuppression, incomplete biliary drainage and bile spillage, conversion to laparotomy, acute cholecystitis/pancreatitis, jaundice, pregnancy, and insertion of prosthetic devices (T tube). For the laparoscopic cholecystectomy without spillage, percutaneous endoscopic gastrostomy (PEG) tube or endoscopic retrograde cholangiopancreatography (ERCP), no antibiotics are recommended unless high-risk patient (see Table 3). The choice of agent is recommended to be co-amoxiclav or cefuroxime and metronidazole. SAP recommendations are for single dose only; however, duration may be up to 24 hours post procedure (Table 3). Vascular surgery such as varicose veins surgery, brachial procedures without prosthesis are not recommended to give SAP and the same rule for minor digit amputation (Table 4). Skin and soft tissue infection prevention; for leg ulcers/decubitus ulcers, topical antiseptics and wound care usually sufficient. Only use systemic antimicrobials if cellulitis present or there is evidence of septicemia. Rule out underlying osteomyelitis if suspected. Interpretation of the culture results with caution. Positive cultures may reflect colonization or infection. Antibiotic prophylaxis is not recommended for prevention of infection in trauma and orthopaedic/arthroscopy surgery without an implant. For minor metalwork insertion operation such as K-wire, screws, small orthopaedics plates, it is recommended to use cefuroxime 1.5 g IV and if patient has penicillin allergy, clindamycin 600 mg IV is given as alternative. Patient with history of MRSA or risk for MRSA is recommended to be given vancomycin as depicted in table 6. In elective major procedures involving metalwork, including joint, pelvic or spinal implants, use cefuroxime 1.5 g IV. And give two additional doses of 750 mg 8 hourly. Antibiotic-loaded cement is recommended for cemented joint replacements in addition to IV antibiotics. In gynaecological surgery, most procedures do not require prophylaxis such as diagnostic laparoscopy, hysteroscopy surgery, and hysterosalpingography (HSG). But if HSG demonstrates dilated fallopian tubes, or history of pelvic inflammatory disease (PID), antibiotic prophylaxis should be given as in Table 7. For abdominal hysterectomy, vaginal hysterectomy, vaginal operations and repairs and surgery that may involve the bowel, use co-amoxiclav 1.2 g IV, If there is penicillin allergy, use gentamycin 3 mg/kg plus métronidazole 500 mg IV. Currently, the teicoplanin is not recommended to be used as prophylaxies but therapeutic, according to the review carried out by the European Medicine Agency (EMA) in 2013-2014.[16]

One of the ways to improve the surgical practice of SAP is auditing antimicrobial prophylaxis in operative theatre for appropriateness of the used antibiotic, its dose, route, timing of initial dose, number of doses, and its documentation in accordance with local hospital guidelines. The study population should include a list of all surgical procedures that may be obtained from theatres database. This list documents a description of the surgery type of all procedures, patient name and hospital identification (ID). Data may be collected retrospectively using patient's medical notes that were provided by the medical records of each department. Patient notes, anaesthesia records, intra-operative reports, operation records and drug charts can be used as well. The recorded data may include: patient details (name, hospital ID, date of birth, gender, weight); name of surgeon and anaesthetist; antibiotic allergies on admission; antibiotics used within seven days of surgery; MRSA screening and result; type of the performed surgery; time

and duration of surgery; peri-operative antibiotics administered and time of first dose; antibiotics continued post-surgery; antibiotics on discharge; and SAP documentation. Surgery time and duration details were obtained from patient management information system (PMIS) as this information was recorded in the medical notes. Data are recorded on the data collection form, which was then anonymized and entered into Statistical Package of the Social Statistics (SPSS), for statistical analysis. Finally, the recommendation is to meet with individual specialities to review and update guidelines, setting targets for the areas for improvement

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Abbreviation list: Hysterosalpingography (**HSG**) , Implantable cardiac device (**ICD**), Intravenous (**IV**), Kilogram (**Kg**), Methicillin-resistant Staphylococcus aureus (**MRSA**), Milligram (**mg**), Normal Saline (**NS**), Pelvic inflammatory Disease (**PID**), Royal College of Physician of Ireland/ Royal College of Surgeon of Ireland (**RCPI/RCSI**), Scottish Intercollegiate Guideline Network (**SIGN**), Statistical Package of the Social Sciences (**SPSS**), Surgical antimicrobial prophylaxis (**SAP**), Surgical site infections (**SSI**), Urinary tract infection (**UTI**)

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