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Prophylactic Antibiotics in Orthopaedic Surgery: Guidelines and Practice

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Summary

The national clinical practice guideline has recommended that prophylactic antibiotic be given in orthopaedic surgery involving joint replacements and internal fixation of fractures. The aim of this study is to assess the current antibiotics prophylaxis practice in a state level hospital. One hundred and three patients (68 males, 35 females; mean age 41.6 ± 22.2 years) undergoing internal fixation for closed fractures and joint replacement surgery were included in this prospective study. The choice of pre and post-operative antibiotics, their dosages and duration of administration were recorded. The pre-operative antibiotics were only deemed to have been given if it was documented in the case notes and in the case of post-operative antibiotics if it was signed on the drug chart. Eighty eight percent were given pre-operative prophylactic antibiotics and 92% were given post-operative antibiotics. For patients undergoing internal fixation of fractures, the most commonly used antibiotic for both pre and post-op is intravenous cefuroxime. For joint replacement surgery, the most commonly used antibiotic is intravenous cefoperazone. The duration or number of doses of post-operative antibiotics was highly variable. It was not stated in 56% of the post-operative instructions. Post-operative antibiotic was ordered for 48 hours or longer in 10%. In conclusion, prophylactic antibiotics appear to be widely practised. The first line antibiotics as recommended by the present guideline were not given in any of the patients. Second generation followed by third generation cephalosporins are the most popular antibiotics, with a trend towards using third generation cephalosporins in arthroplasty patients. Single dose prophylaxis was rarely practised.

Key Words: Infection, Prophylactic antibiotic, Orthopaedic, Guidelines

Introduction

Infection is a catastrophic and one of the most dreaded complications in orthopaedic surgery. Several measures have been undertaken to reduce the risk of infection, one of which is the use of systemic prophylactic antibiotics. Many studies have shown that prophylactic antibiotics reduce the risk of infection where an implant was used[1-5], although the evidence is not entirely undisputed[6]. In surgeries of the hip, Hunfeld *et al*[5] and Southwell-Keely et al[7] concluded that clear evidence does exist regarding the usefulness of antibiotic prophylaxis with first- or second-generation cephalosporins. A review by Gillespie and Walenkamp[8] in 2001 on the effectiveness of prophylactic antibiotics in patients undergoing surgery for hip or other long bone fractures concluded that antibiotic prophylaxis should be offered to those undergoing surgery for closed fracture fixation. They went on to state that on ethical grounds, further placebo controlled randomised trials of the effectiveness of antibiotic prophylaxis in closed fracture surgery are unlikely to be justified.

In Malaysia, there is in fact a national clinical practice guideline on the rational use of antibiotics in

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orthopaedic surgery[9]. The guideline was jointly formulated and endorsed by the Ministry of Health and the Academy of Medicine in 1996. This study was conducted in a state level hospital to determine if prophylactic antibiotic is routinely practised in patients undergoing elective operation for joint replacement surgery and internal fixation for closed fractures, to identify the commonly used antibiotics for prophylaxis, and to critically assess this practice in relation to the national clinical practice guidelines.

Materials and Methods

This was a prospective study conducted between 1st December 2003 and 31st May 2004 in Seremban Hospital. Operations involving open fractures were excluded from the study because in these cases, antibiotics would usually have already been prescribed. The patients undergoing the relevant orthopaedic surgeries were identified from the orthopaedic operating theatre list. In the days following their operation, the relevant data was obtained from the patients' case records and recorded in a standard study form. Data recorded included the patient's demographic details, history of allergies to antibiotics, the diagnosis and the type of orthopaedic operation the patient underwent.

The use of pre-operative antibiotic was determined from the anaesthetic report, the operation notes or the drug chart, and if it was, the choice of antibiotic and dosage was also recorded. In cases where there is no record of any antibiotic having been administered, we considered that pre-operative antibiotic was not given to that particular patient.

The administration of post-operative antibiotics was also assessed. For antibiotics to be administered, it is usually 'ordered' in the post-operative instructions in the operation notes. The antibiotics then have to be 'prescribed' on the drug chart, and administration was confirmed when the nurses signed on the chart after they had done so. We reviewed the notes to see if antibiotics were ordered in the operation notes, and if they were, the antibiotics chosen, dose and duration were all recorded. Following this, the patient's drug chart was checked to determine whether the antibiotic was prescribed on the drug chart and whether the nurses had signed to document that the antibiotics had been given. The antibiotic was only deemed to have been administered if it had been prescribed on the drug chart and a nurse had signed to document that it had been administered.

Results

A total of 103 patients (68 males, 35 females) were included in the study. There were 52 Malay patients, 24 Chinese, 22 Indians, 2 Sikhs, and 3 patients of other races. The mean age of the patients was 41.7 ± 22.2 years (range 13 to 93; median 37 years). Three patients had an allergy to antibiotics. One patient was allergic to tetracycline and Bactrim while the other two did not know the name of the antibiotic they were allergic to.

Internal Fixation for Fractures

There was a total of 86 patients who had surgery for fractures (see Table I). Pre-operative antibiotic was given to 74 patients (86%), all by intravenous (IV) route. Cefuroxime (Zinacef) was given to 39 patients, cefoperazone (Cefobid) 27, and ceftriaxone (Rocephin) 8. Table II shows the dosages that were used for pre-operative antibiotics.

Post-operative antibiotic was ordered in 82 patients (95%) in the post-operative treatment instructions. The post-operative antibiotics ordered intravenously were: cefuroxime in 46 patients, 24 cefoperazone, six ceftriaxone, one metronidazole and cefuroxime, and one cloxacillin. Oral cefuroxime and oral cloxacillin were ordered for two patients respectively. The dosages and duration of post-operative antibiotics ordered are shown in Table III. Eighty patients (93%) were given post-operative antibiotics. Of the six patients not given post-operative antibiotics; it was not ordered in the post-operative instructions in four patients, the antibiotic was ordered in the post-operative notes but not prescribed on the drug chart in one patient, and there was no signature on the drug chart to document that it had been given in the other patient. In addition, cefuroxime was ordered for one day in the post-operative instructions in another patient. However, it was not prescribed on the drug chart. The mistake was recognised on the ward round the following day, and he was given ciprofloxacin subsequently. For the purpose of this study, he was deemed to have been given post-operative antibiotics.

Joint replacement surgery

There were 17 joint replacement surgeries (10 knee replacements and seven total hip replacements). Pre-operative antibiotic was given by intravenous route to all 17 patients (100%) (Table II). Seven patients were given ceftriaxone, six cefoperazone, two patients were given a combination of cefoperazone and gentamycin, and two cefuroxime.

Intravenous post-operative antibiotic was ordered in 16 patients (94%) (nine cefoperazone, five ceftriaxone and two cefuroxime). The dosages and duration of post-operative antibiotics ordered are shown in Table IV. Post-operative antibiotic was given intravenously to 15 patients (88%). Two patients were not given post-operative antibiotics. It was not ordered in one case. This was discovered during the subsequent ward round, and IV ceftriaxone 1g once daily was then prescribed. This was then recorded in the drug chart, but it was not signed to document that it had been given. In the other case, post-operative antibiotic was ordered in the operation notes, but it was not prescribed on the drug chart.

Overall, 91 patients (88%) were given pre-operative antibiotics and 95 patients (92%) were given post-operative antibiotics (see Table V). In three patients, there were instructions for post-operative antibiotics but these were not prescribed on the drug charts. Two of these patients subsequently did not receive post-operative antibiotics while it was recognised in one patient the following day and he was given the antibiotics. Two patients were deemed not to have been given post-operative antibiotics because it was not signed in the drug chart. Only two patients received neither pre-operative nor post-operative prophylactic antibiotics. One was a 19-year-old Chinese man who underwent tension band wiring of a fractured olecranon. The other was a 91-year-old Chinese man who had undergone cannulated hip screw fixation for fracture of the neck of femur.

Patients undergoing joint replacement surgery were more likely than patients undergoing internal fixation of fractures to be given third generation cephalosporins rather than second generation cephalosporins ($p = 0.002$).

Table I: The types of internal fixation for closed fractures and the number of patients

Types of internal fixation	Number of patients
Plating	35
Intramedullary nailing (Interlocking nail / Kuntscher nail)	22 (13 + 9)
Wiring (Kirschner / other types of wiring)	10 (6 + 4)
Hip fixation (Dynamic hip / Dynamic condylar / cannulated screw)	10 (6 +1+3)
Hip hemiarthroplasty	9
Total	**86**

Table II: The types and dosages of the pre-operative antibiotics given to patients who had internal fixation for their fractures and patients who had joint replacement

Types and dosage of antibiotic	Internal fixation Number of patients (%)	Joint replacement Number of patients (%)
Cefuroxime 750 mg	8 (10.8)	0 (0)
Cefuroxime 1 g	1 (1.4)	0 (0)
Cefuroxime 1.5 g	30 (40.5)	2 (11.8)
Cefoperazone 1 g	24 (32.4)	4 (23.5)
Cefoperazone 2 g	3 (4.1)	2 (11.8)
Cefoperazone 2 g + Gentamicin 80 mg	0 (0)	2 (11.8)
Ceftriaxone 1 g	4 (5.4)	2 (11.8)
Ceftriaxone 2 g	4 (5.4)	5 (29.4)
Total	**74**	**17**

Table III: The dosage and duration of the post-operative antibiotics ordered for patients who had internal fixation for their fractures

Types and dosage of antibiotic	Number
IV Cefuroxime 750 mg 8-hourly	18
IV Cefuroxime 750 mg 8-hourly 1 day	12
IV Cefuroxime 750 mg 8-hourly 3 doses	9
IV Cefuroxime 750 mg 2 doses	1
IV 750 mg 8-hourly 3 days	1
IV Cefuroxime 1.5 g 8-hourly	5
Other doses and duration of cefuroxime	5
IV Cefoperazone 1 g 12-hourly	7
IV Cefoperazone 1 g 12-hourly 3 doses	2
IV Cefoperazone 1 g 3 doses	2
IV Cefoperazone 1 g 12-hourly 1 day	2
IV Cefoperazone 1 g 12-hourly 2 days	1
IV Cefoperazone 1 g 12-hourly 3days	5
Other doses and duration of cefoperazone	1
IV Ceftriaxone 1 g daily 3 doses	2
IV Ceftriaxone 2 g daily 2 days	1
IV Ceftriaxone 1 g 12-hourly	1
IV Ceftriaxone 1 g 12-hourly 2 doses	1
IV Ceftriaxone 750 mg 12-hourly	1
Other antibiotics	3
Total	**80**

Table IV: The dosage and duration of the post-operative antibiotics ordered for patients who had joint replacement surgery

Types and dosage of antibiotic	Number
Cefoperazone 1g once daily 2 days	1
Cefoperazone 1g 12-hourly	6
Cefoperazone 1g 12-hourly 3 days	1
Cefoperazone 2g 12-hourly	1
Ceftriaxone 2g daily 2 days	1
Ceftriaxone 1g 12-hourly 3 days	1
Ceftriaxone 1g 12-hourly 2 doses	1
Ceftriaxone 1g 12-hourly	1
Ceftriaxone 1g daily	1
Cefuroxime 1.5 g 1 week (later changed to 750mg 8-hourly 1 week)	1
Cefuroxime 750mg 8-hourly	1
Total	**16**

Table V: Summary of antibiotics administration in the patients

	Pre-operative antibiotic		Post-operative antibiotic			Total number of patients
	Ordered in Op notes	Not ordered Op notes	Ordered in Op notes	Not ordered in Op notes	Actually administered	
Plating +/- K wiring	31	4	33	2	32	35
Intramedullary nailing	19	3	22	0	22	22
K wiring or wire fixation	9	1	9	1	9	10
DHS / DCS / cannulated screw for hip fracture	9	1	9	1	8	10
Hip hemiarthroplasty	6	3	9	0	9*	9
Total knee replacement	10	0	9	1	8	10
Total hip replacement	7	0	7	0	7	7
Total Number of Patients	91	12	98	5	95	103

* - 1 patient was prescribed antibiotics in the operation notes but this was not recorded in the drug chart. The mistake was recognised on the second post-operative day and he was given a different antibiotic.

Table VI: Patient group and the pre-operative antibiotics given for prophylaxis

Patient group	Types of antibiotics given		Total
	2nd generation cephalosporin	3rd generation cephalosporin	
Joint replacement	2	15	17
Internal fixation for fractures	39	35	74
Total	**41**	**50**	**91**

(χ^2= 9.359, df = 1, p = 0.002)

Discussion

It was encouraging to note that prophylactic antibiotics appeared to be widely used in this study, in keeping with the current national guideline. Pre-operative antibiotics were given in 88.3% of patients and 95.1% were meant to receive post-operative antibiotics. In fact, it is likely that more than 88% would probably have received pre-operative antibiotics because in some cases, it might have been given but had not been documented. However, prophylactic antibiotics must be used appropriately, and there are several aspects to the proper usage of prophylactic antibiotics.

Choice of antibiotics

The present national guidelines recommend cloxacilin in combination with gentamicin as the first choice, and a second generation cephalosporin as the second choice antibiotics for prophylaxis in surgery for arthroplasty and open reduction of fractures[9]. None of the patients in this study were given cloxacillin and gentamicin. Preoperatively, cefuroxime was given to 52.7% of those given antibiotics for surgical fixation for fractures, cefoperazone in 36.5%, and ceftriaxone in 10.8%. For patients undergoing arthroplasty, cefuroxime was given to 11.8%, cefoperazone in 47.1%, and ceftriaxone in 41.2%. Therefore, cephalosporins are by far the most popular choice of antibiotics for prophylaxis. The preference for cephalosporins is in fact, worldwide, judging from the overwhelming number of published studies and from the findings of surveys[10-12].

Interestingly, there appears to be a preference for using third generation cephalosporins (cefoperazone and ceftriaxone) for arthroplasty (88.3%) and second generation cephalosporin (cefuroxime) for fracture fixations (52.7%) in this study. Why should a third

generation cephalosporin be chosen for arthroplasty and a second generation cephalosporin for fracture fixation? The spectrum of infecting organisms in surgery for closed fractures is similar to that following prosthetic joint surgery[13]. The most common organisms causing infection are probably still *staphylococcus aureus*, coagulase-negative staphylococcus and gram negative bacilli[14,15]. On theoretical grounds, third generation cephalosporins are less active against Gram-positive bacteria than the second generations, most notably *staphylococcus aureus*, but they are more active against some Gram-negative bacteria[16]. Cefuroxime[17] and ceftriaxone[3,4,18] have both been reported to reduce the incidence of infection in orthopaedic surgery but there has not been any published study on cefoperazone. There has only been one head to head study that we are aware of that has compared cefuroxime and ceftriaxone directly but this was a nonrandomised study of only 60 patients[19]. In practice, it would be extremely difficult to show that an effective antibiotic is statistically superior to another because the rate of infection with prophylaxis is generally already low (less than 3%).

Cost implications

Mazza[4] reported that a single dose ceftriaxone given prophylactically was a cost-effective measure. What is the cost implication of choosing a third generation over a second generation cephalosporin? We are not able to assess the relative cost-effectiveness because we do not know the infection rates with the different antibiotics and the cost of treating an infected case. In terms of the cost of the medication however, third generation cephalosporins are considerably more expensive per dose than second generation cephalosporins. Nevertheless they have the advantage of being longer acting and thus require less frequent dosing. The cost for cefuroxime (Zinacef) is RM13.50 for a 750 mg dose; cefoperazone RM39.00 for a 1 g dose; and ceftriaxone RM49.00 for a 1 g dose (figures from NS Chinese Maternity Hospital & Medical Centre, Seremban). Ceftriaxone can be given once daily, but most of the patients who received ceftriaxone in this study were given twice daily doses. Therefore, the cost of cefuroxime is likely to be quite substantially lower than cefoperazone and ceftriaxone based on current prescribing practice whereby post-operative antibiotics is usually still given to the patients.

Timing and dosage of pre-operative antibiotics

For pre-operative antibiotics, 11 of the 17 patients (64.7%) who had arthroplasty were given double the usual dose recommended for that particular antibiotic. For fracture fixation, 37 of 74 patients (50%) were given double the usual dose recommended for that particular antibiotic. Overall all the patients who received antibiotics were given the recommended dose or a higher dose for that particular antibiotic. Thus, in terms of the dosage, pre-operative dosing appears to be adequate in the patients. In terms of the timing of administration, the antibiotics should preferably be given 30 to 60 minutes before the surgery, or at the induction of anaesthesia or at least ten minutes before inflation of tourniquet[6,20]. Initiating prophylaxis after the skin is incised is ineffective. We know that all the patients were given the antibiotics in the operating theatre, but there was no record to show when the antibiotics were actually given in relation to surgical incision, or inflation of tourniquet. Thus, we were not able to verify the adequacy of this aspect of antibiotic administration.

Duration of antibiotics

The ideal duration of post-operative antibiotics is not so clearly defined, although most studies report that there is no additional benefit when antibiotic prophylaxis was continued beyond 24 hours[5,15,21,22]. The present national guidelines suggest that in principle, a single dose would suffice in most cases. Only four patients were given a single dose of prophylactic antibiotic and it is therefore evident that the guideline is usually not followed. In the arthroplasty patients, the duration or number of doses of post-operative antibiotics was not stated in 10 of 15 patients. In 3 of 15 patients (20%), the antibiotic was ordered for more than 48 hours. In the fracture fixation group, the duration or number of doses was not stated in 44 of 82 patients (53.7%) while in seven patients (8.5%), it was ordered for more than 48 hours. Therefore, it can be seen that the post-operative instructions were often unclear, with the duration or the number of doses required often not stated (Table IV). Where it was stated, there was a great variation, and this probably reflects the current practice in orthopaedics generally. A departmental policy on a regimen for prophylactic antibiotic based on the local antibiotic sensitivity of the common organisms would be ideal as it would also help to clarify and simplify the practice.

In three of 98 patients, the medical and nursing staff in the ward did not follow the post-operative instructions and the post-operative antibiotic was not prescribed on the drug chart. Inadvertent omissions like this, which can happen in a busy setting like this hospital, can be

prevented if the doctors who are writing the post-operative instructions also prescribe on the drug chart at the same time. In two patients, the antibiotics were prescribed on the drug chart, but it was not signed to confirm that they were administered.

How does this study compare to other published studies? In France, the cumulative compliance to the five critical criteria of the French guidelines was 66.9% in those French hospitals which had voluntarily participated in the study. The major compliance failures were in the interval between the first dose and skin incision and the duration of the prophylaxis exceeding 48 hours[23]. In Scotland in 1996, marked differences in prophylactic antibiotic regimens were found between elective primary joint replacements and emergency hip surgery. In the former, there was excellent compliance to policies. In emergency hip surgery on the other hand, half of the consultants did not prescribe antibiotics, and only 33% of the patients were prescribed the schedule that the consultant had wished. Of 48 doses prescribed, five were omitted[24]. In England, a retrospective study found frequent inaccuracies in both pre-operative and postoperative doses. Ten percent were not prescribed post-operative antibiotics although only 7% of patients did not receive any prophylactic post-operative antibiotics. There was also failure to administer the prescribed doses in another 7%. Longer time intervals between doses, and failure of proper documentation were also observed[25]. Therefore, in spite of guidelines the actual practice of prophylactic antibiotic administration in other countries also remains an area which could be improved upon.

Conclusion

Prophylactic antibiotics in elective orthopaedic surgery appear to be widely practised. The first line antibiotics as recommended by the present guideline were not given in any of the patients. Second generation followed by third generation cephalosporins are the most popular antibiotics, with a trend towards using third generation cephalosporins in patients undergoing joint replacement surgery. The duration of post-operative antibiotics was highly variable and single dose prophylactic antibiotic was rarely practised. The practice of prophylactic antibiotics in this hospital is therefore very different from the present guidelines. It can be improved and simplified by adopting a departmental policy which is evidence based and which should be reviewed periodically.

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