Impact of an Educational Program on Antibiotic Use in Paediatric Appendectomy Procedures

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ABSTRACT

Aim: To evaluate antibiotic use in paediatric appendectomy procedures.

Method: Demographic, clinical and antibiotic prescribing data for patients who had appendectomies were reviewed in two paediatric hospitals retrospectively (pre-intervention). The data was analysed against standard guidelines for abdominal surgery. A multifaceted education strategy was designed and administered only in the case hospital. A post-intervention evaluation was conducted in both hospitals (case and control).

Results: 207 cases and 224 controls were evaluated. There was no significant difference ($p > 0.05$) between gender, age and length of stay between the groups. Post-intervention, appropriateness of theatre antibiotics changed from 0 to 65% (cases) and from 52.9% to 53.3% (controls). The appropriateness of ward antibiotics changed from 48 to 84.7% (cases) and 76.4 to 71.4% (controls). The total antibiotic dosage appropriateness changed from 0 to 58.2% (cases) and 12 to 3.8% (controls).

Conclusion: Antibiotic use significantly improved following the multifaceted educational intervention.

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INTRODUCTION

Appendectomy is one of the most common surgical procedures performed in children.[1] Antibiotic prophylaxis for abdominal procedures has been used since the 1940s.[2] Since then, numerous investigations have attempted to define the optimal antibiotic, number of doses and cost-effectiveness of prophylaxis in this field of surgery.[3]

The *Therapeutic Guidelines: Antibiotic* (TG:A) provide recommendations on antibiotic use for a variety of indications including surgical prophylaxis.[4] Initial studies have shown that despite the popularity of these guidelines only a small proportion of antibiotic prescribing complied with the recommendations.[5] Grilli and Lomas have identified the value of guidelines as an acceptable basis for clinical practice.[6] Poor acceptance usually arises from a lack of ownership or where there is difficulty in application at the clinical interface.[6,7]

Paediatrics presents additional challenges in adhering to prescribing guidelines due to the wide range of doses used. Therefore, we set out to investigate whether an educational intervention could be successful in changing antibiotic prescribing in paediatric patients.

The aims of this study were to evaluate antibiotic use in paediatric appendectomy procedures by: determining current drug use, dosage and prescribing patterns; identifying and establishing criteria and standards which describe appropriate drug use; implementing treatment guidelines through targeted education programs; evaluating the impact of the intervention; and analysing the implications of identified non-recommended drug use.

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METHOD

This study was approved by the human ethics committees of Curtin University of Technology, Western Australia, Princess Margaret Hospital for Children, Western Australia, and the Royal Children's Hospital, Victoria. This study was conducted at Princess Margaret Hospital for Children (PMH), a 250-bed paediatric teaching hospital in Perth, and the Royal Children's Hospital (RCH), a 350-bed paediatric teaching hospital in Melbourne.

This study was designed as a pre- and post-intervention analysis. The case patients were identified at PMH and consisted of two groups. One group underwent appendectomy pre-intervention (April 2000 to August 2001) and the other group underwent appendectomy post-intervention (December 2001 to April 2002). Two similar groups of patients were identified at RCH during parallel time periods as the pre- and post-intervention case patients to serve as controls. The rationale for the control group was to determine influences other than the PMH intervention that may have affected antibiotic selection. The surgeons at PMH and RCH were not aware of the study being carried out in their respective hospitals.

An multifaceted educational intervention was implemented at PMH over a four-week period in November 2001. It involved development of antibiotic prescribing guidelines for appendectomy procedures in conjunction with the departments of microbiology, surgery and pharmacy at PMH using the TG:A[8] (Appendix 1); releasing a hospital newsletter with results of pre-intervention antibiotic prescribing plus new guidelines for prophylactic antibiotic use in appendectomy patients; reinforcement of guidelines by pharmacists in the wards; and displaying antibiotic prescribing guideline posters in the wards and theatres. The control patients were not administered the multifaceted educational intervention. Definitions of terms used are outlined in Table 1.

Data was collected from patients' charts and entered onto a form designed for the study. Data collected included demographic details such as age, weight, gender, date of admission, date of discharge, and clinical details such as principal diagnosis and principal procedure plus medication details including drug name, dose, frequency, route and number of doses administered.

The Statistical Package for the Social Sciences (version 11) was used for data analysis. The study design was a pre-post time series incorporating a control group. Post-intervention data were used to evaluate antibiotic prescribing compared with pre-intervention population

Table 1. Definitions of terms used in the study

Term	Definition
Appropriate choice	drug/drug combination prescribed as recommended in the TG:A
Appropriate dose	dose prescribed within ± 25% (variability allowed in dosage forms and bioequivalency studies) of the recommended dosage
Theatre antibiotics	prophylactic antibiotics prescribed in theatre
Theatre dosage	dosage of theatre antibiotics given
Ward antibiotics	post-operative antibiotics prescribed in the ward
Ward dosage	dosage of ward antibiotics given
Total antibiotic choice	choice of drug/drug combination prescribed in the theatre and ward combined
Total antibiotic dosage	total combined dosage of antibiotics prescribed in the theatre and ward
Total appropriateness	appropriateness of a combination of the choice and dosage of antibiotics prescribed in theatre and the ward in accordance with the TG:A or in-hospital guidelines
Non-recommended antibiotics	antibiotics not recommended by the TG:A or in-hospital guidelines

TG:A = *Therapeutic Guidelines: Antibiotic*[8]

undergoing the same procedure. Populations were compared for number of patients included in each group, age and length of stay using independent sample t-tests. Differences in the antibiotic choice, dosage and gender were evaluated using chi-square analysis. One was added to the fields where zero was the result in a cell and analysed using chi-square analysis. Based on a = 0.05 and b = 0.2 with a 20% change in prescribing appropriateness approximately from 60 to 80% require a sample of 80 patients in each group to achieve statistical significance. The control group was analysed for any change over the pre and post total periods of the study.

RESULTS

The study evaluated 207 case patients (102 pre-intervention, 105 post-intervention) and 224 control patients (119 pre-intervention, 105 post-intervention). There were no significant differences in gender or mean age for the cases and controls. In the pre-intervention cases, 57 (56%) were males and the mean age was 10.7 (sd 3.1) years, compared to 62 (59%) males and a mean age of 11.0 (sd 2.9) years in the post-intervention cases.

Length of Stay

The mean length of stay for case patients was 3.5 (sd 2.9) days during the pre-intervention period and 3.8 (sd 2.6) in the post-intervention period (p = 0.42). Although the control group had slightly longer length of stay than the cases, there was no difference between the pre- and post-intervention period (4.5 ± 2.7 vs 4.1 ± 2.5 days) for control patients (p = 0.33).

Theatre and Ward Antibiotic Choice

The number of non-recommended 'theatre antibiotics' decreased after the educational intervention from six to three in the case hospital. Table 2 provides a description of the different types of antibiotics prescribed and the number of times they were prescribed for the case patients. There was a significant reduction in metronidazole use—monotherapy and in combination with other antibiotics. The use of cefotetan increased from zero during the pre-intervention period to 68 (65%) patients during the post-intervention period (p < 0.001).

Table 2. Prophylactic antibiotics prescribed for the case patients

Antibiotic/s prescribed	Pre-intervention	Post-intervention
Cefotaxime	3 (2.9%)	0 -
Cefotetan	0 -	68 (65%)
Ceftriaxone	4 (3.9%)	6 (5.7%)
Metronidazole	24 (23%)	6 (5.7%)
Metronidazole + cefotaxime	8 (7.8%)	0 -
Metronidazole + ceftriaxone	44 (43%)	0 -
Metronidazole + cephamandole	1 (1.0%)	0 -
Timentin	0 -	7 (6.6%)
No prophylaxis	18 (18%)	18 (17%)
Total	102	105

At the control hospital, there was no improvement in the number of appropriate 'theatre antibiotics' prescribed, with 53% of patients receiving non-recommended antibiotics during both study periods (Table 3). There was a significant improvement in the prescribing of appropriate 'ward antibiotics' in the case hospital from 49/102 (48%) during the pre-intervention period to 89/105 (85%) post-intervention (p < 0.001). No changes were observed in the control hospital (Table 3).

Total Antibiotic Choice

In the case hospital, appropriate 'total antibiotic choice' increased from zero during the pre-intervention period to 57% (p < 0.001) post-intervention. No significant improvement was observed in the control hospital.

Number of Theatre Antibiotic Doses

There was a significant decrease in the number of 'theatre antibiotic' doses prescribed after the intervention in the case hospital. The average number of antibiotics prescribed

Table 3. Comparison of antibiotic choice and antibiotic dosage between the case and control groups

	Cases			Controls		
Category	Pre-intervention (n = 102)	Post-intervention (n = 105)	p	Pre-intervention (n = 119)	Post-intervention (n = 105)	p
Appropriate theatre antibiotics	0 -	72 (68%)	< 0.001	63 (53%)	56 (53.3%)	0.25
Appropriate ward antibiotics	49 (48%)	89 (85%)	< 0.001	91 (76%)	75 (71.4%)	0.34
Appropriate total antibiotics	0 -	60 (57%)	< 0.001	43 (36%)	40 (38%)	0.94
Appropriate theatre antibiotic dosage	68/137 (50%)	100/106 (94%)	< 0.001	128/163 (78%)	99/157 (63%)	0.003
Appropriate ward antibiotic dosage	115/317 (36%)	374/429 (87%)	< 0.001	254/427 (59%)	94/192 (49%)	0.859
Appropriate total antibiotic dosage	0/89 -	60/103 (58%)	< 0.001	14/116 (12%)	4/103 (3.8%)	0.084

per patient during the pre-intervention period was 1.6 and decreased to 1.0 post-intervention ($p < 0.001$). In the control hospital, the average number of antibiotics prescribed during both periods was 1.8 ($p = 0.77$).

Antibiotic Dosages

There was a significant improvement in the 'theatre antibiotic', 'ward antibiotic' and 'total antibiotic dosages' post-intervention in the case hospital (Table 3). In the control hospital, there was no change in appropriateness of antibiotic dosage, with the exception of 'theatre antibiotics' where a decrease in the number of patients on appropriate antibiotics was observed.

Total Appropriateness

The number of patients where the antibiotic choice and dose were appropriate in all settings in the case hospital increased from 0/102 (0%) to 46/105 (44%) post-intervention. The improvements in choice and dosage were sustained over the five-month post-intervention period for both theatre and ward antibiotics. There was no change observed in the control hospital with appropriate pre- and post-intervention rates at 5.8% and 0.9%, respectively.

DISCUSSION

Our study has identified that interventions by pharmacists can influence prescribing appropriateness of physicians in a paediatric setting. Several studies have evaluated drug usage in children,[9-11] and in paediatric appendectomy,[12,13] but none have considered appropriateness of dosage prescribing in children.

Prescription of non-recommended antibiotic combinations was common before the intervention but was significantly reduced post-intervention for the case group. The number of 'theatre antibiotic' doses prescribed was significantly reduced and a single dose was administered to every patient in all post-intervention groups. This is in accordance with the TG:A recommendations of a single dose of cefotetan as prophylaxis. This reduces the cost of antibiotics, administration costs, nursing, pharmacist and surgeon's time and, potentially, adverse effects. There was a significant improvement in the prescribing of ward and 'total antibiotic choice' following the intervention. The number of patients on appropriate 'total antibiotic dosage' improved from 0 to 57% (60/105).

Surgeons at PMH also practise at several other hospitals in Western Australia. This made it difficult to evaluate the impact of an intervention at PMH without a contaminated control group. The investigators identified RCH as a site sufficiently distant from PMH. This group controlled for national influences on antibiotic prescribing during the study. Control groups had similar patient characteristics to the case groups.

The randomised controlled trial is considered the gold standard for providing a high level of scientific validity. The methodology used for a randomised controlled trial is not directly applicable to drug use studies involving interventions since the intervention cannot usually be contained or blinded to one group of prescribers. Hence, the pre-post design is the most common approach adopted. The weakness in this design is that change may have occurred as a result of external factors. The design is strengthened by the use of a control group with respect to the intervention. The advantages of retrospective studies are the lack of influences on prescribers. It is advantageous to adopt standard methods to eliminate bias in data collection.

In this study the term appropriateness related to the prescribing of dosage or drug or both in accordance with the guidelines used. The term appropriateness has been defined differently in various studies. A French study which evaluated surgical antimicrobial prophylaxis, used the terms acceptable and unacceptable.[9] A multicentre study on surgical antibiotic prophylaxis in 18 hospitals used the terms 'justified' and 'not-justified'.[10] Tunger et al.[11] used the terms 'rational' and 'irrational' use for antibiotics. The terms defined in other studies have a similar meaning to this study where 'appropriate' and 'inappropriate' use have been used.

Antibiotic Choice and Dosage

During the pre-intervention period (8 March 2001) a Health Department circular was released to all hospitals in Western Australia. It proposed 'supply of third generation cephalosporins (particularly ceftriaxone) to operating theatres should cease wherever possible, and that their use for surgical prophylaxis in operating theatres and for the purpose of peri-operative antibiotic prophylaxis use should be avoided'.

An evaluation of the impact of the circular showed that 35/77 (46%) patients were prescribed ceftriaxone pre-circular and 13/25 (52%) post-circular. There was no significant change ($p = 0.367$) in ceftriaxone prescribing. The circular released during the pre-intervention phase did not, therefore, have an impact on the prescribing behaviour of surgeons evaluated in the pre-intervention group in PMH. However, following the introduction of local treatment guidelines and implementation of the educational intervention in this study, only 6/87 (7%) patients on antibiotics were prescribed ceftriaxone. This supports the belief that locally developed guidelines are more likely to be accepted and followed than those developed regionally or nationally without local input.

Therapeutic Guidelines for Abdominal Surgery

The TG:A recommend that for abdominal surgery, adequate concentrations of antimicrobial must be present immediately prior to surgery.[8] A single dose is usually sufficient unless the procedure lasts longer than three hours. Several alternatives are available, with cefetotan recommended as a single agent at the time of anaesthetic induction.[8] This recommendation was adopted at PMH following consultation with microbiologists, surgeons and pharmacists. The second-generation cephalosporins are used widely in surgical prophylaxis and are a current recommendation for appendectomy procedures.[14-16] In a review article, cefotetan ($n = 389$) had a low rate of infection failure (8.4 ± 2.8)—lower than most other commonly used regimens such as cefoxitin (12%) and cephalothin (43%).[17] An overall assessment of cefotetan was as good or better than combination therapy with respect to overall efficacy.[17] The major advantage of cefotetan was the simplicity of a single dose.

Intervention

Various hospitals have adopted drug use evaluation programs which have resulted in the introduction of educational strategies in an attempt to modify physician prescribing habits.[18,19]

The introduction of a purely educational strategy showed only marginal improvement in overall compliance with recommendations on surgical services.[20] However, when a control strategy was introduced through the use of a pre-printed physician order form in the peri-operative period, there was a dramatic improvement in compliance with recommended antibiotic regimens.[20] D'Eramo et al.[21] reported a short-term improvement when their handbook was introduced in an attempt to modify the patterns of prescribing for empirical therapy. In this study, compliance with the antibiotic guidelines was improved without any of the restrictions evident in these two studies.

Providing feedback to clinicians on their prescribing practices has been a successful technique for achieving behaviour change. Feedback can entail comparisons with peers or standards. As with practice guidelines, feedback may be most effective when the system is developed with local input, where clinicians accept the measures as important, fair, and relevant to their own practices.[18]

There was no significant diminution of the effect of the intervention on the prescribing behaviour for either theatre or ward antibiotic choices or dosages. A randomised controlled trial of academic detailing indicated that face-to-face education of the physician is an effective means of reducing suboptimal prescribing decisions.[22] The differences in prescribing remained highly significant over time, with no sign of reduction in effect nine months after the start of the office-based intervention.

Ideally, the pharmacist should be involved in the monitoring of prescribing, providing information to new doctors and nurses and assisting in the process of drug use review. This requires communication with all newly arrived staff involved in the area, providing information about local antibiotic policies.[23]

CONCLUSION

A multifaceted educational intervention by pharmacists can have a significant effect on antibiotic prescribing. Local guidelines seem more likely to be accepted and followed than those developed nationally. There was no significant diminution of the effect of the intervention on prescribing behaviour during the five months post-intervention. Development of clinical practice guidelines need to be supported by other educational activities.

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Appendix 1. Antibiotic guidelines for appendectomy procedures (Princess Margaret Hospital for Children)

Category	Prophylaxis (at induction)	Inflamed appendix	Peritoneal soiling/peritonitis
Nil allergy patient	cefotetan 50 mg/kg single dose (maximum 1 g)	ticarcillin + clavulanic acid 50 mg/kg (ticarcillin) (maximum 3 g) 2 doses, 6 hours apart	ticarcillin + clavulanic acid 50 mg/kg (ticarcillin) (maximum 3 g) 4 times daily for up to 5 days
Non-anaphylactic penicillin allergy patients	cefotetan 50 mg/kg single dose (maximum 1 g)	ceftriaxone 50 mg/kg (maximum 1 g) single dose with metronidazole 12.5 mg/kg IV (maximum 500 mg) single dose, 6 hours postoperatively	ceftriaxone 50 mg/kg (maximum 1 g) once daily with metronidazole 12.5 mg/kg IV (maximum 500 mg) twice daily for 5 days
Anaphylactic penicillin allergy patients	clindamycin 10 mg/kg IV (maximum 600 mg) with gentamicin 7 mg/kg IV single dose	clindamycin 10 mg/kg IV (maximum 600 mg) 2 doses, 6 hours apart starting 6 hours postoperatively with gentamicin 7 mg/kg IV single dose (if gentamicin given at induction then further dose is not required)	clindamycin 10 mg/kg IV (maximum 600 mg) 4 times daily with gentamicin 7 mg/kg once daily for 5 days