

Antibiotic misuse in a pediatric teaching hospital

E. SCHOLLENBERG, MD; W.L. ALBRITTON, MD, FRCP[C]

Antibiotic use at a pediatric teaching hospital was reviewed for a month. A total of 188 courses of therapy were evaluated with respect to choice of antibiotic, dosage and necessity of treatment. Errors in therapy were noted in 30% of the medical orders and 63% of the surgical orders. The most frequent error, unnecessary therapy, was found in 13% and 45% of the medical and surgical orders respectively. Error rates were highest for the most frequently ordered antibiotics, notably the penicillins. The magnitude of the problem appeared to be similar to that previously reported from general and adult hospitals. The difficulties with solutions such as educational programs and compulsory consultation are discussed.

On a étudié pendant un mois l'utilisation des antibiotiques dans un hôpital pédiatrique universitaire. On a fait l'évaluation de 188 traitements en ce qui concerne le choix des antibiotiques, la posologie et la nécessité du traitement. On a observé des erreurs de traitement dans 30% des ordonnances médicales et dans 63% des ordonnances chirurgicales. L'erreur la plus fréquente, le traitement inutile, a été retrouvée dans 13% des ordonnances médicales et dans 45% des ordonnances chirurgicales. Les taux d'erreur ont été les plus élevés pour les antibiotiques les plus fréquemment prescrits, en particulier les pénicillines. L'importance du problème est semblable à ce qui a déjà été signalé dans des hôpitaux généraux et des hôpitaux pour adultes seulement. Les difficultés de solutions telles que programmes de formation et consultation obligatoire sont discutées.

Antibiotics are unusual among treatment modalities in that their use may have effects beyond the individual patient and the infection being treated. The emergence of resistance and changes in flora are well known to follow the use and abuse of particular agents.¹⁻³ The resulting risks of dangerous nosocomial infection are also well documented.^{4,5} Hence, monitoring antibiotic prescribing should be a continuing priority.

Reviews of antibiotic use have been reported from a variety of hospitals,⁶⁻¹⁴ both teaching and private. These reviews either have involved exclusively adult hospitals or have included pediatric patients as a fraction of the population in a general hospital. Differences between adult hospitals were not impressive, but the degree of misuse was. Given the differences in training and approach between pediatricians and other physicians, the questions we asked were whether antibiotic misuse was as significant in pediatric patients and whether there were qualitative differences in the types of error encountered. While a precise comparison of the results of various series is not meaningful be-

cause of different standards, a review of other audits puts local experience in perspective.

Methods

The Children's Hospital of Winnipeg is a 204-bed, university-affiliated referral centre. All medical patients are admitted under the care of a pediatrician, and all surgical patients under the care of a pediatric general surgeon or a surgical subspecialist.

All antibiotic orders for inpatients received in the pharmacy during December 1978 were reviewed after the completion of therapy. All orders were written by house staff under the direction of the attending physician. These orders involved 188 courses of therapy for 183 patients, 7 of whom had been in hospital prior to that month but had begun a new course of antibiotic therapy. The charts were reviewed by a senior pediatric resident (E.S.) for relevant information available to the prescriber at the time the order was written. This included recorded historical and clinical data, the weight at the time of admission, laboratory and radiologic reports, reports of cultures, records of appropriate cultures done before the institution of antibiotic therapy, relevant ancillary studies (e.g., of renal function) and eventual culture and sensitivity results. The antibiotic orders, including dose, interval, route of administration and duration of therapy, were recorded and the total daily dose per kilogram was calculated.

Each case was then reviewed by a pediatric infectious disease consultant (W.L.A.), with attention to the justification for the antibiotic order, the choice of antibiotic (based on clinical and known bacteriologic information) and the appropriateness of the dosage or the method of administration. Also reviewed were the adequacy of preantibiotic cultures, whether other studies, such as viral serology or renal function tests, were done when appropriate, and whether orders were changed in response to significant culture and sensitivity information.

Each course of therapy was then assigned to one of the following categories according to a modification of the system of Kunin, Tupasi and Craig:¹¹

- 1: The antibiotic use as ordered is agreed with.
- 2: The antibiotic use as ordered is agreed with, but the benefits of this therapy or prophylaxis are controversial.
- 3: The need for antibiotic therapy is agreed with, but a different agent or combination of agents is recommended on the basis of the available clinical data, or culture of a resistant organism did not result in an appropriate change in therapy.
- 4: The need for antibiotic therapy is agreed with, but a different dose, dosing interval, route of administration or duration of therapy is recommended.

From the departments of pediatrics and medical microbiology, University of Manitoba, Winnipeg

Reprint requests to: Dr. W.L. Albritton, Assistant professor, Departments of pediatrics and medical microbiology, University of Manitoba, Basic Sciences Building, Rm. 530, 700 William Ave., Winnipeg, Man. R3E 0Z3

5: The need for antibiotic therapy is disagreed with; that is, there is no evidence of bacterial infection, the condition is self-limiting or prophylaxis is not indicated.

Courses of therapy assigned to categories 1 and 2 were considered appropriate, whereas those assigned to categories 3, 4 and 5 were considered inappropriate.

Results

The results of this review are summarized in Table I.

Antibiotics were prescribed for 39% and 20% of the medical and surgical patients respectively. Errors in therapy were noted for 30% of the medical patients treated. The most frequent error (seen in 13%) was apparently unnecessary therapy (category 5). Usually this involved the use of antibiotics in cases of presumed viral infection (e.g., bronchiolitis and gastroenteritis), in which there was no clinical or laboratory evidence of bacterial infection. Of course in certain patients, such as neonates and patients with neutropenia, any suspicion warrants therapy, and this was considered in the assessment. Nevertheless, there was evident pressure to give an antibiotic to any patient with a fever. The reason for the treatment of 22 children was acute otitis media although 14 had been admitted with asthma, bronchiolitis or gastroenteritis. While clearly these conditions may occur with an upper respiratory tract infection and otitis media, in these patients the evidence for a bacterial infection was poorly documented, and they would not have received antibiotics save for the diagnosis of acute otitis media. One might suspect that this condition was overdiagnosed in these patients because the prescribers sought a reason for antibiotic therapy. In addition, a small number of patients in this group had an infection that was self-limiting and did not require antibiotic therapy — for example, *Salmonella* gastroenteritis.

Unnecessary prophylaxis was the reason for therapeutic error in a large proportion (46%) of the surgical patients who were treated. Although this area is controversial, the current literature offered guidelines that we followed in our assessment.¹⁵⁻¹⁷ These included indications for prophylaxis, the timing of antibiotic administration and which antibiotics were preferred. Of the 16 patients for whom such an error was noted 14 had been given oral antibiotic therapy after otolaryngologic procedures such as tonsillectomy, septo-

plasty and myringotomy. Our review failed to show any benefit of antibiotic prophylaxis in these situations, and its use was considered inappropriate. If these patients are excluded from the total the overall error rate for the surgical patients was 38%.

Errors in the choice of antibiotics (category 3) were noted with almost equal frequency in the medical and the surgical patients. In 9 of the 16 patients with whom such an error was made a second antibiotic was unnecessarily given in addition to the preferred drug, which was usually ampicillin. Most commonly gentamicin or cloxacillin was given in addition to ampicillin for an uncomplicated pneumonia in a patient without apparent added risk. Patients with added risk would include neonates, immunocompromised individuals and patients with chronic chest disease. In three patients the antibiotic was not changed after significant culture of a resistant organism.

Errors in dose, dosing interval, route of administration or duration of therapy (category 4) were noted for 16 patients. Errors in dose, mainly an inadequate amount, were noted for 6 of the 16, and errors in the dosing interval or the route of administration were noted for 3. The latter included an inappropriate dosing interval with cloxacillin and gentamicin, and the intravenous use of erythromycin and tetracycline with insufficient indication. Although the duration of therapy must be individualized in each case, in seven patients therapy was considered unnecessarily prolonged on the basis of the available information.

Among the antibiotics most frequently ordered were ampicillin/amoxicillin, gentamicin, cloxacillin, trimethoprim-sulfamethoxazole and penicillin, in that order. The largest number of errors in therapy involved these antibiotics (Table II). Although erythromycin and tetracycline were prescribed much less frequently, their use was often inappropriate. In contrast, the use of chloramphenicol, carbenicillin and cephalothin, though infrequent, was always appropriate.

The reasons for treatment spanned the pediatric spectrum, as did the errors in therapy. For instance, lower respiratory tract infections appeared to be treated erroneously 37% of the time, either with unnecessary

Table I—Assessment of 188 courses of antibiotic therapy

Service	No. of orders (and % of total surveyed on the service); category*							
	Appropriate			Inappropriate				
	1	2	Sub-total	3	4	5	Sub-total	
Medicine	104 (68)	3 (2)	107 (70)	13 (8)	13 (8)	20 (13)	46 (30)	
Surgery	7 (20)	6 (17)	13 (37)	3 (9)	3 (9)	16 (46)	22 (63)	
Total	111 (59)	9 (5)	120 (64)	16 (9)	16 (9)	36 (19)	68 (36)	

*As defined in the text.

Table II—Number of patient days of antibiotic use and frequency of inappropriate therapy, by antibiotic

Antibiotic	Patient days of use; no. (and % of total)	Total no. of orders	% in error
Ampicillin/amoxicillin	621 (39.6)	122	26.2
Gentamicin	284 (18.1)	48	31.3
Cloxacillin	281 (17.9)	36	22.2
Trimethoprim-sulfamethoxazole	131 (8.3)	20	15.0
Penicillin G or V	124 (7.9)	25	32.0
Chloramphenicol	41 (2.6)	8	0
Carbenicillin	36 (2.3)	5	0
Erythromycin	29 (1.8)	13	76.9
Cephalothin	17 (1.1)	2	0
Tetracycline	4 (0.3)	2	50.0
Neomycin	2 (0.1)	1	100.0
Total	1570	282	

antibiotic therapy in conditions such as bronchiolitis, or with inappropriate combination therapy. Serious infections, such as meningitis, were handled appropriately, although one patient received an unnecessarily prolonged course with a combination of antibiotics.

Prophylaxis was the reason for the treatment of seven medical patients — four with endocarditis, two with granulocytopenia and one with urinary tract infection — and was considered appropriate. On the other hand, 22 surgical patients received prophylaxis and in only five instances was this considered appropriate according to the available information.^{17,18} The errors included unnecessary prophylaxis (in 16 patients) and inappropriate choice of antibiotic (in 1 patient).

Discussion

While it may be granted for the stated reasons that auditing antibiotic use is important, many find it difficult to accept that there are standards against which therapy may be judged.¹⁹ However, it is because of its overall effect that antibiotic use should be especially subject to certain guidelines. Guidelines for dose, the preferred antibiotic and justification for treatment can be arrived at from previous culture and sensitivity data at a particular centre as well as from a review of the literature. This will leave controversial the therapy for a small proportion of cases, but a picture could develop of the overall pattern of use at the centre.

Comparison of reviews from different centres is complicated by differences in technique and standards of care. For instance, in some reviews it was considered inappropriate to continue antibiotic therapy for any condition if the culture reports were negative.¹³ The limitations of culture in infections such as otitis media, certain pneumonias and even osteomyelitis make continued therapy appropriate even without a precise etiologic diagnosis.

After reorganizing the categories, we tried to compare our experience with that at general and adult hospitals reported elsewhere (Table III). While the degree may vary, the overall picture is one of frequent errors of all types at every one of the centres. We did note a somewhat lower use of prophylaxis, espe-

cially in general surgery, among our patients. There was, nevertheless, a large proportion of therapeutic errors in this group.

Accepting that there is room for improvement, we must turn our attention to possible solutions. Direct educational programs of varying extent have had limited effect elsewhere. A reduced frequency of errors in the use of prophylaxis occurred in two studies,^{7,12} but neither report expressed satisfaction with these results. Concerns over toxicity and expense have prompted some centres to put certain antibiotics on a "controlled" list, so that an opinion from an infectious disease consultant is required prior to release of any of those antibiotics from the pharmacy. Although a physician's order could not be overruled, the use of these antibiotics dropped dramatically. When removed from the controlled list the antibiotic was always used more frequently. The striking effect such a second opinion could have reiterates the shortcomings in education and practice in this area.^{11,20}

Another approach was to inform an individual service as to how their antibiotic use and costs compared with those of similar services in the same hospital.²¹ This seemed to discourage the use of the agents so reported, but the use of agents not reported increased.

Clearly, then, a first step in a centre might be to control the use of certain antibiotics. Whereas in other centres this has involved chloramphenicol, carbenicillin, the cephalosporins and sometimes the aminoglycosides, we have found the greatest number of errors to occur with the penicillins, erythromycin and tetracycline. While the latter may be less directly toxic to the patients in whom they are used, their misuse may still have an effect on the hospital flora and their resistance. The question arises whether the use of all antibiotics should be so controlled. The logistics at any centre may preclude this as a workable solution. Also, such an approach fails to address the misinformation that is the basis for the errors described, as noted in the National Antibiotic Therapy Test in the United States.²²

The dilemma of the physician working alone with an acutely ill patient without the security of a second opinion or even certain local laboratory data is real.²³ Obviously there may be limits to how we can apply the standards of a well equipped teaching hospital to some primary care situations. Nevertheless, as a model for pediatric care in our area, we cannot be satisfied if one third of our antibiotic orders are in error by our own standards.

In conclusion, we attempted to document areas of antibiotic misuse in a pediatric teaching hospital. Although there were differences, the overall frequency of error was similar to that reported from several other such reviews. The ramifications of these errors include increased bacterial resistance, changes in hospital flora and unnecessary expense. (We estimated unjustified therapy to account for 10% of the 1978 budget of \$60 000.) It would seem prudent for each centre to review its own problem areas with a view to solutions such as educational programs and compulsory consultation. At any rate, there seems to be a need to

Table III—Comparison of error rates in current study with those reported for general and adult hospitals

	Current study	Achong et al ^{7*}	Jones et al ¹⁰	Kunin et al ¹¹	Roberts et al ¹³
Total no. of orders reviewed	188	179	534	237	340
% in error					
In choice of therapy	9	12	14	27	37
In dose	5	8	7	9	7
In that the therapy was not indicated	19	2	30	17	8
Total†	36	23	51	52	66

*In this study the use of only four antibiotics was reviewed.

†These errors include others assessed by the reviewers; in some instances orders were assigned to more than one category of error.

increase physicians' awareness of the hazards of inappropriate antibiotic use.

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Inhalation of foreign bodies by children: a continuing challenge in management

FRASER M. KEITH,* MD; EDWARD J.P. CHARRETTE, MD; R. BEVERLEY LYNN, MD; TOMAS A. SALERNO, MD

In a review of 19 years' experience with inhalation of foreign bodies by children the 33 patients (mean age 28 months) were found to have presented most frequently with wheezing or coughing, or both, of recent onset, and to have decreased air entry, rhonchi or respiratory stridor, or a combination of these signs. Eighteen children had inhaled a nut, a pea or a bean. The other 15 had inhaled various organic and inorganic objects. All the children underwent bronchoscopy, and the foreign body was completely removed in 19 during the first procedure; the remainder required repeated bronchoscopy or direct surgical removal of the foreign body, or both. Permanent disability or death was not encountered. The findings of the study

indicate that early bronchoscopic removal is the preferred treatment when a child inhales a foreign body.

Lors de la revue de 19 ans d'expérience dans l'inhalation de corps étrangers par des enfants, on a trouvé que les symptômes révélateurs les plus fréquemment présentés chez les 33 patients (dont l'âge moyen était de 28 mois) étaient le sifflement ou la toux, ou les deux, de récent début; ils avaient aussi une diminution d'entrée d'air, des ronchus ou une respiration striduleuse, ou une combinaison de ces symptômes. Dix-huit enfants avaient inhalé une noix, un pois ou un haricot. Les 15 autres avaient inhalé divers objets organiques ou inorganiques. Tous les enfants ont subi une bronchoscopie, et chez 19 d'entre eux on a pu retirer complètement le corps étranger au cours de cette première intervention; les autres avaient besoin d'une bronchoscopie répétée ou la récupération chirurgicale du corps étranger, ou les deux. On n'a rencontré aucun cas d'incapacité permanente ou de décès. Les résultats de cette étude indiquent que le retrait précoce par bronchoscopie est le traitement de choix quand un enfant inhale un corps étranger.

From the department of surgery, Queen's University, Kingston, Ont.

*Resident in general surgery

Reprint requests to: Dr. Tomas A. Salerno, Department of surgery, Kingston General Hospital, 76 Stuart St., Kingston, Ont. K7L 2V7