

Survey of Aerobic Bacterial Infections in Paediatric Surgical Intensive Care Unit Patients

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Abstract

Infections cause a significant amount of morbidity and mortality in paediatric surgical patients requiring intensive care. The study aims to describe the epidemiology of infection among these patients, to correlate the source of infection with the underlying medical condition, and to determine the antibiotic sensitivity pattern of the organisms.

Through a retrospective review over a period of one year, 133 cases were analysed. The overall incidence of infection was 35%. Those who had emergency surgery had the highest infection rate (47%). Respiratory tract infections were the commonest source of infection, and were associated with ventilator therapy rather than the underlying medical condition.

*The Enterobacteriaceae were the most common isolates seen. From antibiotic sensitivity tests, the empirical antibiotics of choice are gentamicin for suspected gram-negative infection and vancomycin for severe infections where methicillin-resistant *Staphylococcus aureus* is a likely cause. A high rate of resistance to ampicillin was seen and its use as a first-line monotherapy drug should be discontinued in our patient population.*

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Key words: Antibiotic sensitivity, Empirical antibiotic therapy, Epidemiology of infection, Morbidity, Mortality

Introduction

Data on infections in paediatric surgical patients are few in the literature. Although there are many studies on infection in adult surgical and paediatric medical patients, paediatric surgical patients are a special group in their spectrum of diseases and treatment requirements.

The study aims to firstly describe the epidemiology of infection in this group of patients within the intensive care unit (ICU) setting. The second was to find any correlation between the source of infection and the underlying medical condition so as to institute preventive measures. Finally, we wanted to find the antibiotic susceptibility pattern of the offending organisms so as to form a protocol for empirical antibiotic therapy.

As anaerobic cultures were not consistently obtained, the study was limited to the analysis of aerobic bacterial infections.

Materials and Methods

This is a retrospective review. All patients admitted or transferred to the four-bedded paediatric ICU at the

Singapore General Hospital from 1 January to 31 December 1995 were included in the study. Data on age, sex, reason for admission, duration of ICU stay, diagnoses, and type of infection were collected, together with details of surgery, antibiotic treatment and placement of invasive lines.

Details of the positive culture results were obtained from the data file in the microbiology laboratory, providing information regarding the site of culture, organisms and their antibiotic sensitivities. Cases with infection were defined as those with at least one positive culture result. Survival outcome at the end of the ICU stay was noted.

Results

A total of 155 cases were admitted or transferred to the paediatric surgical ICU during the study period. Case records were available for study in 133 of the cases.

Patient Profile

ICU patients accounted for 4.9% of the total admis-

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sions ($n = 3169$) to the paediatric surgical unit in our hospital during the period of study. These patients had an age range from 0 to 16 years. They were divided into 6 groups: <1 month, 1 month to 1 year, >1 to 3 years, 4 to 6 years, 7 to 12 years and >12 years (Fig. 1). The median age was 6 months. Seventy-four per cent were 3 years or younger. Four per cent were above 12 years of age and these cases had been on follow-up since they were under 12 years of age. Racial characteristics were similar to that of the Singapore population. There were 87 (65%) Chinese, 29 (22%) Malays, 15 (11%) Indians and 2 (2%) of other races.

Primary Diagnosis

Fifty-nine per cent ($n = 78$) of the cases were admitted for a gastrointestinal pathology. Examples included pyloric stenosis, gut atresias such as oesophageal atresia with tracheo-oesophageal fistula, perforated appendicitis and incarcerated inguinal herniae. Hepatobiliary, genitourinary and oncological diagnoses each accounted for 7.5% ($n = 10$) of the admissions. The remaining diagnostic categories were haematological 5.3% ($n = 7$), respiratory 4.5% ($n = 6$) and others 9.0% ($n = 12$).

Indication for Admission

The indications for admission to the ICU were emergency surgery in 69 cases (51%), emergency without surgery in 12 (10%) and after elective surgery in 52 (39%) for postoperative monitoring. Emergency cases were those admitted from the Accident and Emergency Department and referrals from other hospitals or units within the same hospital.

Incidence of Infection

Thirty-five per cent of ICU patients had infection ($n = 46$) compared with 3.7% (112 out of 3014) of the paediatric surgical patients not admitted to the ICU. The ICU patients were further divided into three groups

according to the reason for admission:

- 1) emergency surgery;
- 2) emergency without surgery; and
- 3) following elective surgery.

The incidence of infection was 47%, 23% and 15% respectively in each group (Fig. 2). Using the chi-square test, the infection rate in the first group was significantly higher than in either of the latter two groups, with a P value of 0.0069 when compared with group 2 and a P value of 0.034 when compared with group 3. The difference in infection rates between groups 2 and 3 was not significant ($P = 0.55$).

Patients who had infection had a longer duration of stay in the ICU, with a median of 3 days and an inter-quartile range of 2 to 5 days. The range was from 1 to 55 days. Those without infection stayed a median of 2 days, with an inter-quartile range of 1 to 3 days and a range of 1 to 15 days. As the distribution of values was skewed, the Mann-Whitney rank sum test, a non-parametric test, was used to compute significance. Patients with infection had a significantly longer length of stay in the ICU ($P = 0.0011$).

Source of Infection

Respiratory tract infections were the commonest source of infection, with the majority arising in patients on ventilator therapy (Table I). Those who had vascular lines were generally ill, with some requiring multiple lines. The infection rate from urinary catheter insertion was lower, with 3 positive urine cultures among the 65 cases with catheters.

When the site of infection was correlated with the primary diagnosis of the patient (Table II), we found that respiratory tract infections ($n = 9$) were still the commonest source of infection in cases with a gastrointestinal condition. Eight of these were on ventilator therapy. Of those with positive peritoneal fluid cultures, 4 had ap-

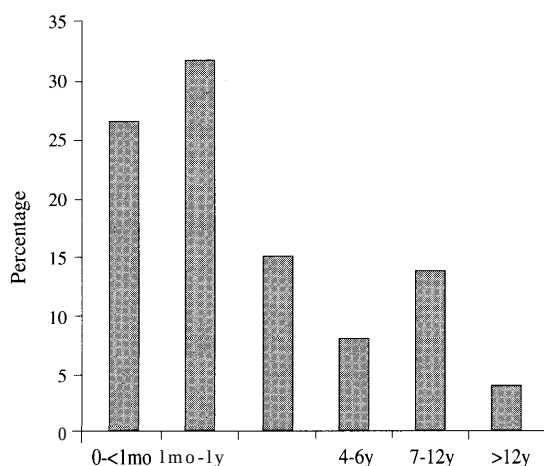


Fig. 1. Age distribution of paediatric surgical ICU patients

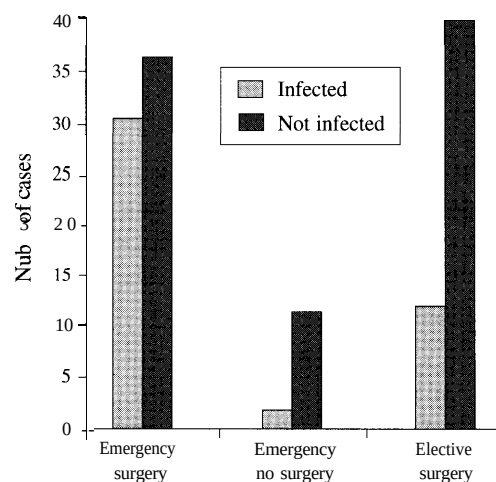


Fig. 2. Distribution of patients with infection

TABLE I: USAGE OF INVASIVE LINES AND SITE-SPECIFIC INFECTION

	No. of cases	Median duration in days (Range)	Infection by site
Ventilator	47	2 (1 to 19)	13 respiratory
Central venous line	26	6 (1 to 59)	4 blood
Venous long line	10	12.5 (3 to 55)	2 blood
Arterial line	33	2 (1 to 24)	3 blood
Urinary catheter	65	2.5 (1 to 44)	3 urine

pendicitis whilst the rest had intussusception, perforated ascending colon and omphalocele. Interestingly, the 3 cases with a gastrointestinal diagnosis and positive cultures from their wounds all had elective surgery for anorectal malformation.

Bacteria Isolated

Gram-negative organisms were the commonest isolates, with *Klebsiella spp*, *Escherichia coli* and *Pseudomonas aeruginosa* being the most frequent (Table III). Coagulase-negative *Staphylococcus* and methicillin-resistant *Staphylococcus aureus* (MRSA) were also common. These are organisms known to cause bacteraemia.

Antibiotic Sensitivity

The antibiograms for the following organisms were analysed: *Klebsiella spp*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Enterobacter spp*, *Acinetobacter baumannii*, *Enterococcus spp*, coagulase-negative *Staphylococcus* and both

methicillin-sensitive and resistant *Staphylococcus aureus*. Among the gram-negative organisms, resistance to aminoglycoside antibiotics such as gentamicin and amikacin was generally low (Table III), except for *Enterobacter spp* and *A. baumannii*. Resistance to ampicillin, a commonly used first line antibiotic, was high. The gram-positive organisms, except methicillin-sensitive *Staphylococcus aureus* (MSSA), had a high resistance to the penicillin group of antibiotics. There was no vancomycin resistance among the isolates.

Survival Outcome

There were 6 (4.5%) deaths in the ICU, all of whom had been on ventilator therapy. Five cases had infection, with respiratory infection as the cause of death in 4 cases.

Discussion

Bacterial infections account for the majority of ICU infections.' Compared to adult ICU patients where the infection rate was 44.8% in the European Prevalence of Infection in Intensive Care (EPIC) study,² the rate of infection was lower in our paediatric surgical ICU. Patients in the paediatric surgical ICU are predisposed to infection due to their poor general condition and the use of multiple invasive lines. The infection rate was significantly higher in cases admitted for emergency surgery, possibly because of the poorer general condition on admission and the underlying primary condition. As in the EPIC study, there was a correlation between the rate

TABLE II: SITES OF POSITIVE CULTURES IN RELATION TO UNDERLYING DIAGNOSIS

Site of first positive culture	Site of primary diagnosis						
	Gastrointestinal	Hepatobiliary	Genitourinary	Oncology	Respiratory	Haematological	Others
Blood	4	1					
Urine	4		1				1
Stool	2						
Respiratory	9	1		1	2		3
Fluid	8 (peritoneal)	1 (bile)					
Wound	3			1		1	2
Tissue	1						

TABLE III: THE NINE MOST FREQUENT CULTURE ISOLATES AND THEIR ANTIBIOTIC SENSITIVITIES

Organism	n	Gentamicin		Amikacin		Ampicillin		Penicillin		Cloxacillin		Vancomycin	
		S	R	S	R	S	R	S	R	S	R	S	R
<i>Klebsiella spp</i>	12	9	1	4	3	0	10	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested
<i>Escherichia coli</i>	11	8	1	6	1	5	4	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested
<i>Pseudomonas aeruginosa</i>	8	6	2	7	1	0	0	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested
Coagulase-ve <i>Staphylococcus</i>	8	1	4	Not tested	Not tested	0	8	0	8	3	5	6	0
MRSA	7	Not tested	Not tested	Not tested	Not tested	0	6	0	6	0	6	6	0
<i>Enterococcus spp</i>	5	Not tested	Not tested	Not tested	Not tested	3	2	3	2	Not tested	Not tested	4	0
<i>Enterobacter spp</i>	4	2	2	1	1	0	4	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested
MSSA	4	Not tested	Not tested	Not tested	Not tested	3	1	3	1	4	0	Not tested	Not tested
<i>Acinetobacter baumannii</i>	4	2	2	2	2	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested	Not tested

MRSA: methicillin-resistant *Staphylococcus aureus*; MSSA: methicillin-sensitive *Staphylococcus aureus*; S: sensitive; R: resistant

of infection and duration of ICU stay, with a higher infection rate seen in the long stayers. Here, incidence was used instead of the one-day prevalence used in the EPIC study. However, a cause-effect relationship cannot be proven.

Respiratory tract infections are the commonest source of infection in the adult ICU,^{3,5} with viruses being the most common cause of such infection in the paediatric age group.⁷ Ventilator therapy places the patient at increased risk of pneumonia.^{1,6} In our study, ventilator therapy was found to be a more important determinant of pneumonia than the underlying medical condition. Intubation, by bypassing the host's natural airway defences, predisposes to aspiration of the microorganism from the stomach or oropharynx.^{4,7}

Among the microorganisms isolated, the Enterobacteriaceae⁸ remain the most common, as has been found in other studies.^{2,3,9} Similarly, a high frequency of *Pseudomonas aeruginosa* was found.

Microbiological confirmation of the causative organism and antibiotic sensitivity testing in our hospital requires at least 48 hours. In the interim, empirical antibiotic therapy would be based on the epidemiology of the microbiological flora within the ICU. From the results, gentamicin is recommended as the drug of choice in gram-negative infection. In the USA, gentamicin is already used in combination with other antibiotics in the empirical therapy of serious perioperative infections.¹⁰

As for the gram-positive bacteria, coagulase-negative *Staphylococcus*, *Enterococcus spp* and MRSA were found to be uniformly sensitive to vancomycin. Cloxacillin is recommended for MSSA. In severe infections where MRSA is a likely cause, empirical vancomycin therapy may be life-saving. Ampicillin, a commonly used first-line antibiotic in our ICU, had a low efficacy in the initial treatment of infection in our patients. In the antibiotic protocols mentioned above,¹⁰ ampicillin was omitted.

As most epidemics originate in ICUs, effective infection control programmes need to be developed. Antibiotic guidelines help to target at causative microorganisms and minimise the selection of antibiotic-resistant strains.

With the above results, changes have been implemented in the paediatric surgical ICU. Frequent bronchial suction, chest physiotherapy and maintenance of asepsis in the ventilator circuit¹ are measures aimed at preventing ventilator-associated pneumonia. Gentamicin is being used as the first-line drug in suspected gram-negative sepsis. Discontinuation of the use of ampicillin as a first-line drug will avoid unnecessary antibiotic usage. However, the epidemiology of infection is constantly changing and further surveillance studies are needed.

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