A Study of Bacterial Cultures and their Antibiotic Sensitivities in a Paediatric Ward Population

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SUMMARY

This study reflects the bacterial infection prevalent in a general paediatric ward and assesses bacterial sensitivity to a number of antibiotics. Staphylococci were the commonest bacteria cultured and were almost entirely insensitive to penicillin. While 2% of all Gram-negative bacteria were insensitive to gentamicin, bacterial resistance to other commonly used antibiotics varied between 28% and 62%. Malnutrition or its associated ills enhanced the chances of infection with Gram-negative bacteria. It is recommended that gentamicin, penicillin and a penicillinase-resistant antibiotic be given to all seriously ill, malnourished children in whom infection is either overt or suspected on the grounds of pyrexia, shock or deteriorating clinical condition.

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Due to the increasing problem of bacterial resistance to antibiotics and the frequent need to initiate therapy before microbiological diagnosis is available, a register of all positive bacterial cultures and their antibiotic sensitivities was maintained in one of the general paediatric wards of a hospital dealing with Black patients (Baragwanath Hospital).

The aims of the study were threefold: (*a*) to determine the prevailing pattern of bacterial infection; (*b*) to establish what role, if any, age and nutrition played in the type of bacterial infection; and (*c*) to ascertain the antibiotic sensitivity and resistance of commonly encountered organisms, and thereby to establish a rational approach to antibiotic therapy.

MATERIALS AND METHODS

All and only positive bacterial cultures obtained from 210 children aged 0 - 10 years during a period of 18 months were recorded. Blood cultures were done when there was unexplained fever or where the severity of the illness suggested a septicaemia. Cultures from the rectum, cerebrospinal fluid, ears, throat and skin were taken when there was gastro-enteritis, meningitis or evidence of local sepsis. The specimens were inoculated into nutrient broth, blood agar and MacConkey's media. Throat swabs were also inoculated into a Loeffler's slope and a tellurite medium (Hoyle's). The usual selective media, such as Selenite F broth, Salmonella-Shigella agar, resoxycholate and Chapman's media were used for rectal swabs.

Antibiotic susceptibility was determined by the single disc diffusion method using the following antibiotics: gentamicin, carbenicillin, kanamycin, nitrofurantoin, ampicillin, chloramphenicol, streptomycin, and more recently, trimethoprim sulphamethoxazole. The incidence of Gram-negative (G−) and Gram-positive (G+) organisms cultured from miscellaneous sites as well as from blood cultures in particular, was recorded. The response of G+ infections to most antibiotics is generally good, therefore antibiotic sensitivities to organisms other than the coagulase-positive staphylococci are not reported in this study. Coagulase-positive staphylococci were tested against penicillin and cloxacillin only.

An expected greater incidence of G− infections among children, together with the frequent need to start treatment before culture results become available, prompted us to combine all G− bacteria grown from the blood as well as other sites and to establish their collective sensitivity to the test antibiotics. The age and nutritional status of all patients were recorded. Where the weight for age fell below the third Boston percentile, nutrition was regarded as poor.

RESULTS

Three hundred and twenty positive cultures from miscellaneous sites were obtained from 210 patients. A single organism was grown from a single site in 149 children, while more than one organism was cultured from either the same or several different sites in the remaining 61 cases. Of the 320 cultures 87 were grown from the blood and represented 33% of all blood cultures taken during the period of the survey.

The frequency with which different bacteria were recovered from miscellaneous sites and from blood cultures is depicted in Table I, which also demonstrates the comparative frequency of G+ and G− infections. The staphylococcus was the organism most commonly found both from the blood—37 cultures (43%), and from combined sites—107 cultures (33%). Among enteral infections, *Salmonella* and *Shigella* together constituted the next most common group of bacteria.

It is evident from Table I that G− organisms were grown more frequently than G+ bacteria.

Twenty-four children from whom 48 bacteria were cultured acquired their infections in hospital. There were

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TABLE I. BACTERIAL TYPING OF 320 CULTURES

Gram-negative organisms	All sites	Blood
Salmonella/Shigella	45	15
E. coli	39	9
Proteus	30	2
P. pyocyaneus	20	8
Klebsiella	13	5
Influenza	7	0
Other	27	7
	181 (57%)	46 (53%)
Gram-positive organisms		
Staphylococci	107	37
Pneumococci	14	—
Streptococci	18	4
	139 (43%)	41 (47%)

18 coagulase-positive staphylococci, 7 *E. coli* and 4 *Salmonella* cultures, while the remaining organisms were *Pseudomonas pyocyaneus, Proteus* strains, *Klebsiella* and *Streptococcus faecalis*.

Tables II and III show the influence of nutrition on the recovery of G+ and G− organisms. A higher incidence of G+ infections for both the total series and the blood culture series was evident among well-nourished children (51% and 58% respectively). In the group of 132 poorly-nourished children, who constituted the bulk of the patients, there were more infections with G− bacteria—an incidence of 61% in cultures from all sites, and 59% in the blood culture series.

TABLE II. NUTRITION AND BACTERIA CULTURED FROM ALL SITES

Good nutrition		Poor nutrition	
Gram-positive	59 (51%)	Gram-positive	80 (39%)
Gram-negative	57 (49%)	Gram-negative	124 (61%)
	116 cultures		204 cultures

TABLE III. NUTRITION AND BACTERIA CULTURED FROM BLOOD

Good nutrition		Poor nutrition	
Gram-positive	19 (58%)	Gram-positive	22 (41%)
Gram-negative	14 (42%)	Gram-negative	32 (59%)
	33 cultures		54 cultures

The age distribution in the two nutrition groups is shown in Table IV. Infants younger than 6 months who are prone to G− infections constituted 55% of the well-nourished cases, and only 40% of the poorly-nourished children. A more detailed analysis of the role of age in infections with G+ and G− organisms in the two nutrition groups is depicted in Table V. In the group with good nutrition G+ and G− infections occurred with almost

TABLE IV. AGE DISTRIBUTION IN TWO NUTRITION GROUPS

Age	Good nutrition		Poor nutrition	
< 1 month	23	55%	10	40%
1 - 6 months	20		42	
7 - 12 months	9	45%	18	60%
13 - 23 months	2		31	
24 months and over	24		31	
	78		132	

TABLE V. INFLUENCE OF AGE AND NUTRITION ON BACTERIAL CULTURES

	Good nutrition		Poor nutrition	
Age	Gram-positive	Gram-negative	Gram-positive	Gram-negative
<6 months	32 (50%)	32 (50%)	33 (45%)	40 (55%)
>6 months	27 (52%)	25 (48%)	47 (36%)	84 (64%)

equal frequency, both among young babies (less than 6 months of age) and older children. G− infections were commoner at all ages among poorly-nourished children. Fifty-five per cent of young infants and 64% of older children, who are generally less vulnerable to G− organisms, suffered from the latter infections. .

TABLE VI. STATISTICAL ANALYSIS

Group	Variables	χ^2	P
Good nutrition	Organisms Age	0,13	>10% NS
Poor nutrition	Organisms Age	1,42	>10% NS
<6 months	Organisms Nutrition	0,47	>10% NS
>6 months	Organisms Nutrition	4,1	< 5% Sig.
Combined age group	Organisms Nutrition	4,6	< 5% Sig.

NS = not significant; Sig. = significant.

The result of the chi-squared test is set up in Table VI. The distribution of G+ and G− organisms on an age basis is not statistically significant in either children younger or older than 6 months. In infants under 6 months nutrition does not play a significant statistical role in the distribution of G+ and G− organisms. In the age group above 6 months, there is a significantly higher incidence of infection with G− bacteria among badly nourished children. The same also applies to the entire test population irrespective of age. These conclusions are also borne out by a test on the significance of the difference in proportions of G+ and G− organisms for the various age groups.

The antibiotic sensitivity of the isolated staphylococci is shown in Table VII. This reveals an almost complete insensitivity to penicillin, 94% being penicillin-resistant. When the antibiotic sensitivities of 181 G− bacteria from all sites were contrasted with 46 G− bacteria cultured from the blood, the percentage resistance to each of the antibiotics studied was very similar in the two groups (Table VIII).

TABLE VII. PERCENTAGE RESISTANCE OF STAPHYLOCOCCI

	No. of bacteria tested	No. of bacteria resistant	% resistance
Cloxacillin	**104**	**0**	**0**
Penicillin	**104**	**98**	**94**

Gentamicin resistance was found to be uncommon—2% for the total and 4% for the blood cultures. Resistance to chloramphenicol was 28% among G− bacteria from miscellaneous sites and 29% from blood cultures. G− bacterial resistance to the other antibiotics varied from 33% resistance to kanamycin to as high a level as 62% resistance to ampicillin.

DISCUSSION

Organisms, as well as their antimicrobial susceptibilities, vary in different geographical locales. These differences may be influenced by factors in the host as well as the antibiotics to which the bacterial strains have been exposed. Most of the infections in this survey were present at the time of admission, and very few of these patients had received antibiotic therapy as outpatients. In these children we were unable to assess what effect, if any, such treatment had in determining the strains of organisms that were recovered. Coagulase-positive staphylococci were the commonest organisms cultured from miscellaneous sites as well as the blood. Although 83% were probably domestic staphylococci, being present at the time of admission, these bacteria were almost entirely insensitive to penicillin but retained their sensitivity to cloxacillin.

In this study, G− organisms were grown more frequently than G+ bacteria, and this tendency was more marked among the malnourished children. The high incidence of *Salmonella* septicaemia, as well as *Salmonella* and *Shigella* cultures from the bowel, would suggest that the malnourished subject is particularly prone to enteric infection and has impaired ability to confine such infections to the gut. The role of other adverse factors such as inadequate sanitation and poor hygiene as a cause of bowel infection could not be assessed.

Mortality in infantile malnutrition remains high. Almost two-thirds of the children in this series were malnourished and fell below the third Boston percentile for weight. Several surveys have shown that acute bacterial infection in malnutrition is common and worsens the prognosis. Thus, Smythe and Campbell[1] in Cape Town found positive blood cultures in 16 of 25 children dying of malnutrition, and in only 9 of 53 survivors. Phillips and Wharton[2] from Kampala investigated bacterial infection in kwashiorkor and marasmus and found evidence of infection in all 32 malnourished children who were thought to be clinically infected. The mortality in these children was 22%, compared with a 5% mortality among 39 children thought to be non-infected. In 21 of the non-infected cases no pathogens were recovered, while the rest had a variety of minor infections. In both series the most severe infections were due to G− organisms, and gut infections were particularly troublesome.

More recently Axton and Giles[3] isolated significant organisms at autopsy from blood and lung cultures in 55% of children dying from malnutrition; 70% of these were classed as G−.

In this series 54 of the 87 positive blood cultures were obtained from malnourished children and 33 from the well-nourished group. Among the 54 children with malnutrition, 11 died (20%), 4 with *E. coli*, 3 with *Staphylococcus pyogenes*, 2 with *Pyocyaneus* infections and the remaining 2 children each had a *Klebsiella* and *Salmonella* septicaemia. Three of the 33 well-nourished children died (9%), 1 with *Staphylococcus pyogenes* in the blood, while *Serratia* and *Proteus vulgaris* were cultured from the blood of the other 2 patients.

We were unable to evaluate the pathogenicity of all the organisms cultured. Many bacteria such as *Serratia, E. cloacae*, etc. are generally of low virulence, but nevertheless, when harboured by a malnourished subject, may assume significance.

In this study all G− bacterial species were combined for the presentation of susceptibility data, and while it is appreciated that a G− pneumonia would have a different significance to a G− skin infection, nevertheless there was

TABLE VIII. PERCENTAGE ANTIBIOTIC RESISTANCE OF GRAM-NEGATIVE BACTERIA

	All sites (181 bacteria)		Blood (46 bacteria)	
Antibiotic	No. tested	% resistance	No. tested	% resistance
Gentamicin	**170**	**2**	**46**	**4**
Carbenicillin	**165**	**42**	**46**	**41**
Kanamycin	**168**	**33**	**46**	**31**
Nitrofurantoin	**144**	**35**	**46**	**45**
Ampicillin	**168**	**61**	**46**	**62**
Streptomycin	**161**	**60**	**46**	**54**
Trimethoprim sulphamethoxazole	**115**	**44**	**30**	**49**
Chloramphenicol	**165**	**28**	**46**	**29**

a strikingly low incidence of resistance to gentamicin among all the G− bacteria cultured. What practical issues are involved in these results? To what extent can laboratory findings of antibiotic resistance influence our choice of antibiotics?

The clinical response to antibiotics was difficult to evaluate in our cases, as many children had double infections, while some received more than one antibiotic. In others aggravating factors such as malnutrition and fluid and electrolyte imbalance increased the total body burden of disease.

It is certainly an accepted fact that an antibiotic which does not look promising in the laboratory may nevertheless achieve a satisfactory effect *in vivo*. The response may be the result of suppression of bacterial growth by high dosage, allowing the patient's own immunological resources to fight the infection. In malnourished children, immunological responses may be impaired,[4] and so the treatment of superadded infection becomes critical, but there is little agreement on when to treat and with what to treat. Children with overt infection should be treated, and patients in whom infection may be suspected on such grounds as pyrexia, shock, and deteriorating clinical condition should, in our opinion, have urgent antibacterial coverage, preceded by blood cultures. Other cases should be screened for pyuria or chest infection, and treatment given in accordance with the findings.

The results of this study would suggest that when there is a clear-cut need for an umbrella of antibiotics gentamicin, penicillin, as well as a penicillinase-resistant antibiotic should be used.

Organisms and their antibiotic susceptibility may vary in different areas and resistance is often proportional to the frequency with which a particular antibiotic is used. It is thus evident that continued surveillance is necessary.

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ADDENDUM

Coagulase-positive staphylococci were tested for penicillin sensitivity using a concentration of 5 μg penicillin per disc. In view of the high rate of penicillin insensitivity (94%), the SAIMR Laboratory at Baragwanath Hospital have since checked to ensure that all penicillin discs were potent, and that every batch of organisms was tested against a known sensitive strain of staphylococcus. In addition the concentration of penicillin in discs was increased to 10 μg. During April 1974 only 34 of 223 coagulase-positive staphylococci cultured in this laboratory were sensitive to penicillin, viz. a resistance rate of 85%.

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