Anaerobic Infections in Children: a Prospective Survey

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Over an 18-month period, cultures from 95 infants and children yielded 146 anaerobic organisms in 110 clinical specimens. *Bacteriodes* was the most frequently isolated anaerobe, followed by *Propionibacterium* and *Clostridium* species. Intra-abdominal sources, soft tissues, and blood were the three major sources (82%) of isolation of anaerobes. Whereas most patients (58%) were over 5 years of age and only 11% were newborns, anaerobic infections constituted a rather uniform proportion of all infections, regardless of sources, in all age groups. Anaerobes accounted for only 2.9% of all positive cultures encountered from the various sources. Rates of recovery of anaerobes from intra-abdominal sources were significantly the highest, and from soft-tissue infections they were significantly the lowest. The anaerobic bacteremias observed were of no clinical significance when *Propionibacterium* species were isolated; however, recovery of other anaerobes from the blood, and primarily *Bacteroides* species, was usually associated with clinical disease. Except in blood cultures, anaerobes almost invariably coexisted with facultative bacteria.

The role anaerobes play in human infections has passed from relative obscurity to widespread appreciation. Advances in anaerobic laboratory technology and availability of simplified anaerobic cultivation and identification procedures have contributed greatly to this increased appreciation (7, 12, 14). There are several reviews of anaerobic infections in the recent literature (2, 3, 5, 8, 9, 15). Most of the patients in these reviews have been adults. Anaerobic bacteria were recovered from almost half of the culturally positive unselected specimens from varied sources (15), and these organisms were incriminated in 8 to 11% of bacteremias (5, 15). In 1968 a review of *Bacteroides* infections in children listed only 26 recorded cases (19). Since then a few more reports of anaerobic infections in infants and children have appeared (6, 10). In one report, anaerobes accounted for 26% of all cases of neonatal bacteremias (6). However, the overall prevalence of anaerobic infections in infants and children has not been studied adequately. The present report is a review of a prospective survey of the anaerobic infections at the Children's Hospital of Michigan over an 18-month period, September 1973 to February 1975.

MATERIALS AND METHODS

During the study period a systematic attempt was made to recover anaerobes from all blood cultures, from specimens of intra-abdominal origin, from paracentesis fluids, and from infected soft tissues. Occa-

sionally, specimens from other sources were cultured for anaerobes. Peripheral venous blood (2 to 5 ml) was inoculated, at the patient's bedside, into bottles containing 50 ml of Columbia broth with 0.05% sodium polyanethol sulfonate under CO₂ and partial vacuum. In the laboratory the blood culture bottles were incubated, without venting, at 35 C. The bottles were inspected daily, and, after Gram-stain examinations of broth from ones showing definite or suspicious growth, subcultures to appropriate solid media were made and incubated aerobically and anaerobically. All bottles were subcultured routinely on days 2 and 7 of incubation. The broth from each bottle was subcultured on a 10% sheep blood agar plate (tryptic soy agar base), incubated anaerobically, and on a chocolate agar plate incubated in an atmosphere of 5% CO₂. Anaerobiosis was achieved with the GasPak system.

Body fluids and material from soft tissues were transported immediately to the laboratory in gassed-out anaerobic containers (Anaswab tubes and Anaport bottles, Scott Laboratories, Fiskeville, R.I.). In the laboratory these were cultured on 10% sheep blood agar plates and colistin-nalidixic acid blood plates, aerobically and anaerobically, and on chocolate agar plates incubated in 5% CO₂. In addition, part of the material was inoculated into a tube containing brain heart infusion broth with 0.1% agar. When the broth showed visible growth, Gram smears were made and subcultures were done aerobically and anaerobically on appropriate solid media.

All plates used for primary isolation of anaerobes were maintained in an oxygen-free atmosphere prior to use.

Further identification of anaerobes was done at

the anaerobe laboratory of the Microbiology Department, Wayne State University Medical School. Biochemical identification of anaerobes was accomplished according to the procedures outlined by Dowell and Hawkins (7), and gas chromatographic identification was performed according to the Virginia Polytechnic Institute system (12).

Most of the patients with positive cultures were seen during hospitalization, and their records were reviewed to determine the significance of the isolation of the anaerobic organisms. All patient records were reviewed and correlated with the clinical isolates.

RESULTS

In the 18-month period under review, 146 anaerobic organisms were recovered in 110 specimens obtained from 95 patients. Table 1 shows the relative distribution of the various groups of anaerobes and the sources from which these organisms were isolated. Gram-negative bacilli were the most frequent group (43%). *Bacteroides* was the single most common genus and alone accounted for 38% of all anaerobic organisms isolated. Gram-positive sporeless bacilli were next in frequency (25%), and most of these were *Propionibacterium* species. The genus *Clostridium* and gram-positive cocci each made up 14% of the anaerobic isolates. Gram-negative cocci were relatively infrequent.

Further classification of the *Bacteroides* isolates was possible in 44 instances. *Bacteroides fragilis* accounted for 77% of the identified species, and among these *B. fragilis* subsp. *fragilis*

was the most common (21 isolates). Of the 21 clostridia isolated 16 were *Clostridium perfringens*, 3 were *C. sporogenes*, 1 was *C. ramosum*, and 1 was not identified further.

Table 1 also depicts the sources of isolation of the anaerobic organisms. Most of these organisms (44) were recovered from intra-abdominal sources such as the serosal surfaces of inflamed appendixes, perforated appendixes, intra-abdominal abscesses, and, occasionally, peritoneal fluid. Soft-tissue infections (wounds and abscesses) yielded almost as many anaerobes (41). Blood cultures yielded the third largest number (35) of anaerobes. Isolates from these three sources accounted for 82% of all the anaerobes recovered. Whereas anaerobes were also recovered from the respiratory tract (seven), intravenous fluids and catheters (six), central nervous system (five), bone and joint (five), ear discharge (one), dental abscess (one), and urine (one), such isolation was relatively infrequent.

Six of the respiratory tract anaerobic isolates were from lung tissue obtained at autopsy in five cases. The seventh isolate was from a tracheal aspirate obtained shortly before death from a patient whose lung tissue yielded the same organism at postmortem. All five cases were immunologically deficient, only one had histopathological evidence of acute pneumonitis, and multiple microorganisms (facultative and anaerobic bacteria, viruses, and *Pneumocystis carinii*) were demonstrated in all.

TABLE 1. Distribution of anaerobes recovered from 95 patients (110 specimens) among various sources

Organisms	No. of isolates from:				Total isolates from all sources	
	Intra-abdominal sources	Soft tissues	Blood	Miscellaneous sources	No.	%
Gram-negative bacilli						
<i>Bacteroides</i>	26	15	4	11	56	38.3
<i>Fusobacterium</i>	1	3	2	1	7	4.8
Gram-positive sporeless bacilli						
<i>Propionibacterium</i>	1	3	18	1	23	15.8
<i>Bifidobacterium</i>	1	1	2	0	4	2.8
<i>Eubacterium</i>	2	0	1	0	3	2.0
<i>Lactobacillus</i>	1	1	0	0	2	1.4
<i>Actinomyces</i>	0	0	0	1	1	0.7
Not identified further	1	2	0	0	3	2.0
Gram-positive sporulating bacilli						
<i>Clostridium</i>	4	10	2	5	21	14.4
Gram-positive cocci						
<i>Peptococcus</i>	4	2	2	1	9	6.3
<i>Peptostreptococcus</i>	3	1	2	2	8	5.5
<i>Gaffkya</i>	0	0	0	2	2	1.4
<i>Megasphaera</i>	0	0	1	0	1	0.7
Gram-negative cocci						
<i>Veillonella</i>	0	3	1	2	6	4.0

No organism was found exclusively in any one source (Table 1). The most common site of isolation of *Bacteroides* was intra-abdominal sources. *Clostridium* species were most commonly isolated from soft tissues, and the genus *Propionibacterium* was primarily recovered from blood cultures. Furthermore, except for blood cultures, *Bacteroides* was the most common genus recovered from any source.

In Fig. 1 the age distribution of patients and the sites from which anaerobes were recovered are shown. There were relatively few newborns; only 11 of the 95 cases belonged to this age group. Children over 5 years of age constituted the majority (58%). Positive blood cultures were encountered in all age groups and in relatively similar numbers. Anaerobes from intra-abdominal sources predominated in children between 5 and 15 years of age and were also frequent in newborns. The recovery of anaerobes from intra-abdominal sources in newborns and in older children was a reflection of the occurrence of necrotizing enterocolitis and appendicitis, respectively, in the two age groups. Soft-tissue infections, although seen in almost all the age groups, were relatively more common in the older children.

The distribution of cases by age groups and by sites of isolation shown in Fig. 1 reflects only the overall prevalence of anaerobic infections as seen in this population. To assess whether anaerobic infections are more or less frequent in any particular age group or from any particular source, a comparison of the rates of recovery of anaerobes to those of all bacteria from various sources is shown in Table 2. It can be noted that anaerobes account for a small proportion of all positive cultures from any site in all age groups. Indeed, in a total of 16,027 cultures processed from the indicated sources during the study period, anaerobes accounted for only 2.9% of the 3,898 positive cultures. The lowest yield of anaerobes was noted in soft-tissue infections in newborns (0.5%), and the

highest yield was from intra-abdominal sources in children between 1 month and 5 years of age (14.8%).

The numbers of anaerobic isolates from any one source among the age groups indicated were quite variable (Table 2). However, the differences in the rates of recovery of anaerobes from a particular source were not statistically significant among the various age groups. Thus anaerobic infections constitute a rather uniform proportion of all infections of a particular site throughout infancy and childhood.

Differences in the rates of recovery of anaerobes from various sources were also observed (Table 2). The recovery rate of anaerobes from intra-abdominal sources (7.4%) was significantly more than from any other source ($P < 0.01$). On the other hand, soft-tissue infections yielded anaerobes (1.4%) significantly less often than any other source ($P < 0.01$). The differences in rates of recovery of anaerobes from blood and from miscellaneous sources was not statistically significant ($P > 0.25$).

During the 18-month study period, 8,248 blood cultures were processed (Table 2). Of these, 883 (10.7%) were positive for all organisms and 34 (0.4%) were positive for anaerobic organisms. Cultures positive for anaerobes constituted only 3.9% of all positive blood cultures. The 35 anaerobes recovered from the 34 blood cultures are listed in Table 1 (column 3). The genus *Propionibacterium* accounted for most of the anaerobic isolates from blood. There appeared to be no relationship between the positive blood culture and the clinical illness in any of the 18 patients from whom the 18 propionibacteria were recovered. In three patients yielding four anaerobes from blood cultures, a definite association between their clinical illness and the bacteremia could be established. A 17-year-old male who was in chronic renal failure and whose transplanted kidney had to be removed because of ureteric infarction had two blood cultures positive for *Bacteroides*. He recovered after chloramphenicol therapy. A 9-year-old male, while receiving clindamycin and gentamicin after surgery for a ruptured appendix, became febrile. His blood culture yielded *B. fragilis* subsp. *distasonis*, which was resistant to clindamycin. Chloramphenicol was substituted for clindamycin and the patient recovered uneventfully. An 11-year-old male with stem cell leukemia, in relapse, became febrile, and *Fusobacterium glutinosum* was recovered from one of two blood cultures. He improved after treatment with appropriate antibiotics.

Five other patients whose blood cultures yielded six anaerobes (*Peptostreptococcus* and *C. ramosum* in one patient, and *Peptostrepto-*

FIG. 1. Number of cases yielding anaerobes in relation to age and source.

TABLE 2. Cultures positive for anaerobes in comparison to all positive cultures from various sources at different ages

Age group	Intraabdominal sources			Soft tissues			Blood			Miscellaneous sources		
	No. processed	No. positive for all bacteria	No. positive for anaerobes (%) ^a	No. processed	No. positive for all bacteria	No. positive for anaerobes (%)	No. processed	No. positive for all bacteria	No. positive for anaerobes (%)	No. processed	No. positive for all bacteria	No. positive for anaerobes (%)
<1 month	51	43	3 (7)	278	215	1 (0.5)	1,599	207	6 (2.9)	1,495	196	2 (1)
1 month-5 years	45	27	4 (14.8)	1,081	917	10 (1.1)	3,986	456	14 (3.1)	1,956	246	10 (4.1)
>5 years	552	309	21 (6.8)	958	762	16 (2.1)	2,663	220	14 (6.4)	1,363	300	9 (3)
All ages	648	379	28 (7.4)	2,317	1,894	27 (1.4)	8,248	883	34 (3.9)	4,814	742	21 (2.8)

^a Percentage of cultures positive for all bacteria.

coccus, *Peptococcus*, *Bifidobacterium*, and *Megasphaera*, each from four different patients) were treated with antibiotics and had an uneventful course. However, the clinical significance of their bacteremias was uncertain. In the remaining seven cases from whom the other seven anaerobes were recovered, no antibiotic treatment was instituted, and their bacteremias could not be ascribed any clinical significance.

Anaerobes were recovered from blood cultures of six neonates, and in all six instances the bacteremias appeared to be insignificant.

Anaerobic organisms were usually found in association with other microorganisms. Of the 146 anaerobes isolated, only 42 organisms (28%) were recovered in pure culture. The remaining 104 isolates (72%) were recovered in mixed culture: 10 in association with other anaerobes only, 44 in association with facultative organisms only, and 50 in association with other anaerobes and facultative bacteria. A notable exception was the genus *Propionibacterium*, of which 18 of 23 isolates were in pure culture and 17 of the 18 were from blood.

The number of anaerobes recovered per culture varied depending on the source of the specimen. In blood and miscellaneous sources, a single anaerobe was recovered in 97 and 86% of the cultures, respectively. However, in intra-abdominal sources and in soft tissues, a single anaerobe was isolated in only 53 and 51% of the cultures, respectively. In almost half of the cultures from the latter two sources, two or more anaerobes coexisted.

In intra-abdominal sources, anaerobes, frequently two or more, were invariably found in association with facultative bacteria. Perforated appendixes and appendiceal abscesses accounted for almost all the intra-abdominal

sources. As would be expected, enteric gram-negative bacilli, primarily *Escherichia coli*, were the facultative anaerobes most often found in intra-abdominal sources. Staphylococci and beta-hemolytic streptococci, on the other hand, were recovered predominantly from soft-tissue infections.

DISCUSSION

The recovery of anaerobes from clinical specimens is dependent on several equally important factors, which include proper collection of material, appropriate oxygen-free transport, and meticulous laboratory technique. Whereas many recent reports emphasize the increasing detection of anaerobic bacteria from clinical material (4, 15, 22), there is insufficient information regarding the frequency of anaerobic infections in the pediatric population.

The overall prevalence of anaerobic infections observed in the present study was surprisingly low. Only 110 cultures, of a total of 3,898 positive cultures (2.9%) encountered after processing 16,027 specimens, contained anaerobes. This low rate of recovery of anaerobes in infants and children is in marked contrast to the much higher rates reported in adult populations (8, 9, 15). However, a recent report from St. Louis Children's Hospital (L. Dunkle, T. Brotherton, and R. Feigin, Abstr. Midwest Soc. Pediatr. Res., October 1975, Abstr. no. 8) also suggests that anaerobic organisms cause a small proportion of infections in a general pediatric population. Furthermore, in another report of 70 cases of anaerobic gram-positive coccal infections in a mixed adult and pediatric population, only six patients were 19 years or younger and none was under 9 years of age (18). A probable explanation for this difference may be related to the fact that underlying conditions that

predispose to anaerobic infections in an adult population are less commonly encountered in a pediatric age group. Such predisposing conditions include chronic pulmonary disease, alcoholism, a variety of gastrointestinal disorders, and a number of genital tract diseases peculiar to adult females. Whether other undetermined factors may also be responsible awaits further elucidation.

In this report, the rate of recovery of anaerobes from intra-abdominal cultures was significantly higher than from cultures of any other site. Moreover, this source yielded the largest number of anaerobic bacteria, as would be expected based on the bacterial ecosystem of the gastrointestinal tract. The majority of intra-abdominal infections yielding anaerobes followed necrotizing enterocolitis in newborns and appendicitis in older children, respectively. Whereas one or more anaerobes can be isolated from cultures of intra-abdominal infections, the role of these organisms in the pathogenesis of such infections is still debatable (17). In our material, as in many others, anaerobes were always found in association with facultative organisms in intra-abdominal sources. Despite this almost constant association at this location, the relative role that each plays in the pathogenesis of mixed infections is undetermined. Experimental models have demonstrated the role of facultative organisms in the pathogenesis of certain "anaerobic" infections (16). Unless the role anaerobes play in mixed intra-abdominal infections can be delineated, the true pathogenesis of such infections cannot be ascertained. Definition of the roles of both facultative and anaerobic bacteria, and understanding their interactions, are essential prerequisites for a rational approach to antimicrobial therapy. Such routine therapy may even be questioned, since in instances of appendiceal perforation in children the use of antibiotics does not seem to improve the outcome or reduce complications (20).

The possibility of associated anaerobic bacteremia in the presence of intra-abdominal infection should not be ignored. In 43% of *Bacteroides* bacteremia reported by Chow and Guze (5) the gastrointestinal tract was the portal of entry. Indeed, of two clinically significant *Bacteroides* septicemias encountered in this series, one followed surgery for a ruptured appendix.

Whereas the number of cultures yielding anaerobes and the total number of anaerobic bacteria recovered were comparable in soft-tissue infections and in intra-abdominal infections, the rate of recovery of these organisms from soft-tissue infections was significantly lower.

Here again, when anaerobes were recovered from soft-tissue infections, facultative bacteria coexisted frequently. The role of anaerobes in gas gangrene, in certain abscesses, and in non-clostridial crepitant cellulitis is easily recognized (9). The presence of anaerobic bacteria in human bites, in perineal wounds, and in abdominal wounds after bowel or genital tract surgery is understandable, although of unproven significance. Anaerobes in mixed culture in superficial wounds at other body sites are perhaps the ones that have the least clinical significance.

Anaerobes in general are responsible for 8 to 11% of bacteremias (5, 15), and in neonates they are reported to be responsible for an even higher proportion. Tyler and Albers (21) noted cord blood bacteremia in 30 of 319 (9.4%) newborns studied; 13% of these bacteremias were due to anaerobes. Chow et al. (6) reported that 26% of 89 cases of neonatal bacteremia was caused by anaerobes; however, specimens obtained from cord blood accounted for 35% of their anaerobic bacteremias. In our experience, where only peripheral venous blood was cultured, anaerobes accounted for 2.9% of neonatal bacteremias and for 4.2% of positive blood cultures in children over 1 month of age. A similarly low recovery rate of anaerobes from blood cultures has been reported recently from another pediatric center. Dunkle et al. (Abstr. Midwest Soc. Pediatr. Res., October 1975) recovered anaerobes from only 0.75% of all blood cultures, and these organisms accounted for clinically significant bacteremic episodes in 8.7% of the instances in neonates and in 4.8% in older children. Differences in patient populations at these various centers and the anatomic sites selected for obtaining blood cultures may account for these wide ranges in the rates of recovery of anaerobes from blood.

Half (18 patients) of the anaerobic bacteremias in our patients were due to *Propionibacterium* species, which are part of the normal skin flora and are generally considered contaminants. Although on rare occasions these organisms have been reported to cause disease (1, 13), propionibacteria appeared to be of no clinical significance in any of the cases reported here. Only a fourth of our cases of anaerobic bacteremia (eight patients) had a definite or a probable clinical illness. In the other fourth (seven patients), despite the recovery of potentially pathogenic anaerobes from blood, there appeared to be no significant relation to the clinical illness. Thus in our experience, anaerobic bacteremia is uncommon among the pediatric population and its significance is clear in

only a small percentage of the instances.

Routine anaerobic blood cultures are definitely indicated when bacteremia is suspected in certain high-risk situations such as after intra-abdominal surgery in immunosuppressed patients, in patients with malignancies, and in those with primary gastrointestinal disease. In other instances, and when only a single blood culture bottle is available, it is perhaps best to vent such a bottle, but do both aerobic and anaerobic routine subcultures.

Anaerobes can be responsible for infections elsewhere in the body. Brain abscesses, osteomyelitis, dental abscesses, sinusitis, lung abscesses, empyema, endocarditis, and urinary tract infections are some such infections reported in adults (9). Anaerobic bacteria have been recovered from 11 to 35% of brain abscesses (9), and in one series an isolation rate of 89% was reported (11). In the series reported here, only a few isolates from sources other than soft tissue, intra-abdominal sites, and blood were encountered. Miscellaneous anaerobic infections of clinical significance were noted in only seven of our patients: two with osteomyelitis and one each with brain abscess, ventriculitis, urinary tract infection, otitis, and periodontal abscess. Cultures of the brain abscess yielded four different anaerobes simultaneously. No significance could be ascribed to cultures of lung tissue obtained at postmortem. Similarly, recovery of anaerobes from central venous catheters and from intravenous fluids was of no clinical significance and probably represented environmental or skin contamination.

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LITERATURE CITED

- Balfour, H. H., and S. L. Minken. 1971. Liver abscess due to *Corynebacterium acnes*. Diphtheroid as pathogen. Clin. Pediatr. (Philadelphia) 10:55-58.
- Bartlett, J. G., and S. M. Finegold. 1974. Anaerobic infections of the lung and pleural space. Am. Rev. Respir. Dis. 110:56-77.
- Bodner, S. J., M. G. Koenig, and J. S. Goodman. 1970. Bacteremic bacteroides infections. Ann. Intern. Med. 73:537-544.
- Bornstein, D. L., A. N. Weinberg, M. N. Swartz, and L. J. Kunz. 1964. Anaerobic infections: review of current experience. Medicine 43:207-232.
- Chow, A. W., and L. B. Guze. 1974. Bacteroidaceae bacteremia: clinical experience with 112 patients. Medicine 53:93-126.
- Chow, A. W., R. D. Leake, T. Yamauchi, B. F. Anthony, and L. B. Guze. 1974. The significance of anaerobes in neonatal bacteremia: analysis of 23 cases and review of literature. Pediatrics 54:736-745.
- Dowell, V. R., Jr., and T. M. Hawkins. 1974. Laboratory methods in anaerobic bacteriology. Center for Disease Control, Atlanta, Ga.
- Finegold, S. M., and J. E. Rosenblatt. 1973. Practical aspects of anaerobic sepsis. Medicine 52:311-322.
- Gorbach, S. L., and J. G. Bartlett. 1974. Anaerobic infections. N. Engl. J. Med. 290:1177-1184, 1237-1245, and 1289-1294.
- Harrod, J. R., and D. A. Stevens. 1974. Anaerobic infections in the newborn infant. J. Pediatr. 85:399-402.
- Heineman, H. S., and A. I. Braude. 1963. Anaerobic infections of the brain: observations on eighteen consecutive cases of brain abscess. Am. J. Med. 35:682-697.
- Holdeman, L. V., and W. E. C. Moore (ed.). 1972. Anaerobe laboratory manual. Virginia Polytechnic Institute and State University Anaerobe Laboratory, Blacksburg.
- Kaplan, K., and L. Weinstein. 1969. Diphtheroid infections of man. Ann. Intern. Med. 70:919-929.
- Martin, W. J. 1971. Practical method for isolation of anaerobic bacteria in the clinical laboratory. Appl. Microbiol. 22:1168-1171.
- Martin, W. J. 1974. Isolation and identification of anaerobic bacteria in the clinical laboratory: a 2 year experience. Mayo Clin. Proc. 49:300-308.
- Moore, W. E. C., and W. B. Gross. 1968. Liver granulomas of turkeys: causative agents and mechanisms of infection. Avian Dis. 12:417-422.
- Page, M. I. 1974. Beware—the anaerobe bandwagon. N. Engl. J. Med. 290:338-339.
- Pien, F. D., R. L. Thompson, and W. J. Martin. 1972. Clinical and bacteriologic studies of anaerobic gram-positive cocci. Mayo Clin. Proc. 47:251-257.
- Sanders, D. Y., and J. Stevenson. 1968. Bacteroides infections in children. J. Pediatr. 72:673-677.
- Shandling, B., S. H. Ein, J. S. Simpson, C. A. Stephens, and S. K. Bandi. 1974. Perforating appendicitis and antibiotics. J. Pediatr. Surg. 9:79-83.
- Tyler, C. W., and W. H. Albers. 1966. Obstetric factors related to bacteremia in the newborn infant. Am. J. Obstet. Gynecol. 94:970-976.
- Wilson, W. R., W. J. Martin, C. J. Wilkowske, and J. A. Washington II. 1972. Anaerobic bacteremia. Mayo Clin. Proc. 47:639-646.