Microflora of Abdominal Sepsis by Locus of Infection

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Specimens from 152 abdominal infections were examined to determine which groups of endogenous bacteria participate in infection emanating from different sites in the gastrointestinal tract. A notable finding was the predominance of anaerobic microflora from infections of ischemic versus perforated small bowel. Empiric antibiotic treatment for ischemic bowel should include focused coverage for anaerobes.

Intra-abdominal infections commonly result from organ perforation. These infections are usually polymicrobial, involving both anaerobic and facultative bacteria. The number and species of bacteria involved in any particular intra-abdominal infection are dependent on the site of perforation and the endogenous bacteria found in the perforated organ (5-7). The facultative organisms most commonly isolated from intra-abdominal infections are reported to be Escherichia coli and Enterococcus faecalis, with Bacteroides spp. (especially Bacteroides fragilis), peptostreptococci, and clostridia reported as the most frequent anaerobic isolates (1, 5, 6). However, these reports do not associate causative organisms with their probable origins. The current study correlated the species of recovered bacteria and the site of intestinal leakage.

Over a 10-year period, 222 clinical specimens from intra-abdominal infections were cultured. The specimens were aspirates or swabs, depending on the amount of material available, of peritoneal or abscess fluid collected during surgery and transported within 2 h of collection to the Surgical Microbiology Research Laboratory. They were inoculated onto prerured anaerobic agar plates (Center for Disease Control formulation) with sheep erythrocytes (sRBCs), with laked sheep blood, kanamycin, and vancomycin, and with sRBCs and phenylethyl alcohol (Remel, Lenexa, Kans.) in a Coy anaerobic chamber. These media were incubated at 35°C for 48 h in the chamber prior to colony type isolation. Anaerobic isolates were identified by the methods described by Holdeman et al. (4) supplemented by descriptions of more recently described species as published in the International Journal of Systematic Bacteriology. The specimens were also inoculated to Trypticase soy agar with sRBCs, MacConkey agar, and Columbia agar with sRBCs, colistin, and nalidixic acid (Difco, Detroit, Mich.). These media were removed from the chamber and incubated in ambient air at 35°C for 24 h. Aerobes were identified by conventional methods (2). Determination of the source of infection was made by the surgeon at the time of surgery.

The source of infection for 152 patients was determined to be due to a perforation at a site in the gastrointestinal (GI) tract: 44 from stomach or duodenum, 11 from small bowel, 57 from appendix, and 34 from perforations of the cecum, colon, or rectum. Ischemic small bowel was the diagnosis for an additional six patients. The microflora of the infections increased in complexity as the perforation site progressed along the GI tract (Table 1). Aerobic species predominated in infections resulting from proximal perforation sites, whereas anaerobic species predominated in those from distal sites.

A total of 1,188 bacterial strains were recovered, of which 420 represented over 50 facultative species, with 768 strains from over 95 strictly anaerobic species. Table 2 presents the predominant flora that we recovered. Because of the differences in the numbers of specimens in each category, the data are presented as the percentage of specimens yielding the listed organisms. Table 3 lists the percentage of specimens yielding the major pathogens E. coli, E. faecalis, B. fragilis, Clostridium perfringens, and peptostreptococci.

It is clear that intra-abdominal infections are caused by the presence of bacteria endogenous to the intestinal tract. The microflora of the intestine is very complex, both in the variety of species present and in total numbers. The stomach and duodenum typically have bacterial concentrations of less than 105 CFU/ml, composed of predominately of gram-positive, aerobic organisms such as streptococci, lactobacilli, and fungi. The small bowel shows increasing numbers of bacteria from the jejunum (105 to 106 CFU/ml) to the lower ileum (108 CFU/ml), with a change in composition of flora near the ileocecal valve, likely because of the backwash of colonic bacteria through the valve. It is in the distal ileum that gram-negative species begin to outnumber gram-positive species, with enteric organisms consistently present along with anaerobic bacteria such as members of the genera Bacteroides, Bifidobacterium, Fusobacterium, Clostridium, and Eubacterium. The microflora of the colon is extremely complex and is composed of over 400 species, 99% of which are anaerobic. The bacterial concentration is in the range of 109 to 1012 CFU/g of feces. The predominant genera are Bacteroides, Bifidobacterium, and Eubacterium (8).

The bacteria that spill into the abdominal cavity do not all cause infection. Although members of the genera Bifido-

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<th>TABLE 1. Compositional recovery from five sources</th>
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<tr>
<td>Stomach or duodenum</td>
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<td>Ischemic small bowel</td>
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<td>Colon or rectum</td>
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bacterium and Gemella are often isolated, they are not considered primary pathogens. The results of the present study indicate that the predominant flora of infections reflects the flora at the site of leakage. However, some of the organisms that are part of the normal intestinal flora and that are considered pathogens in other types of infections (i.e., actinomycetes and fusobacteria) are not frequently recovered from intra-abdominal infections.

Although E. coli and B. fragilis are considered the most significant intra-abdominal pathogens, the data presented here indicate that this is true only for infections resulting from lower GI spillage. Normal oral flora were much more likely to cause infections emanating from the upper GI tract. The exception to this pattern was infection caused by ischemic small bowel. The number of anaerobic isolates recovered from these infections was significantly higher than those recovered from perforated small bowel infections ($x^2$ test of homogeneity, $P < 0.001). In ischemic small bowel infections, clostridia (especially C. perfringens) and E. coli play a major role. These results are consistent with those reported by Baron et al. (3), who found that the number and diversity of the microflora of gangrenous appendicitis was greater than those of the microflora of acute appendicitis, an infection of shorter duration.

The treatment of intra-abdominal infections is most effective with a combination of surgical intervention and antibiotic therapy. The choice of antibiotic agent should be made upon consideration of the source of infection and the probable participating species. In the case of ischemic bowel, the high incidence of clostridia indicates the need for antibiotic therapy that is effective against these organisms.

**REFERENCES**


