Antibiotic Treatment for Surgical Peritonitis

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The charts of 480 patients with secondary bacterial peritonitis were reviewed. The antibiotics used were compared with the culture and sensitivity data obtained at surgery, and the outcomes of patients were evaluated. Patients treated with a single broad-spectrum antibiotic had a better outcome than patients treated with multiple drug treatment. Inadequate empiric antibiotic treatment was associated with poorer outcome than any other type of treatment. The outcome of this inadequate treatment group could not be improved by any antibiotic response to culture and sensitivity information after operation. Those patients treated with antibiotic coverage for anticipated organisms and having no cultures taken did as well as patients having cultures taken. Surgeons typically ignore culture data after operation, and only 8.8% of patients in this study had an appropriate change in antibiotic treatment after operation. A benefit from obtaining operative cultures could not be identified.

THE NECESSITY OF obtaining cultures of the peritoneal cavity of patients with acute abdominal infections is held to be an absolute necessity by many surgeons. It is considered axiomatic that identification of the organisms present and their antibiotic sensitivities is vital to the care of the patient after surgery. Examining the results of intraoperative cultures, evaluating the organisms' sensitivities, and making appropriate adjustments of antibiotic coverage are assumed to be necessary for good patient care. Now that the use of broad-spectrum antibiotics has become commonplace in the treatment of patients with peritonitis, the routine use of operative cultures has been questioned.[1,2] In an attempt to evaluate the actual use of cultures and sensitivity results and their impact on patient care, we retrospectively examined the charts of patients operatively treated for community acquired bacterial peritonitis in Albuquerque, New Mexico for the period January 1, 1987 to December 31, 1989.

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Materials and Methods

The complete spectrum of the patient population at the five largest hospitals was evaluated, for the period January 1, 1987 to December 31, 1989, by reviewing all cases from the University of New Mexico Hospital, the Veterans Administration Hospital, Lovelace Medical Center, Presbyterian Hospital, and St. Joseph Hospital.

Patients with acute onset of peritonitis requiring operative therapy were our target population. Patients with perforated appendicitis, perforated diverticulitis, gangrenous or perforated gallbladders, gangrenous bowel that was potentially resectable for cure, perforated ulcer disease, and small bowel perforations with established intra-abdominal infection were included in the study. Patients with peritonitis related to peritoneal dialysis, infected ascites, and liver failure, primary peritonitis from a distant site, peritonitis incompletely or previously treated with antibiotics, and peritonitis occurring after an elective operation with antibiotic coverage were excluded.

Microbiologic laboratory reports, physician progress notes, physician orders, operative reports, and pathology reports were evaluated in detail. Dates and results of microbiology testing were compared with type and duration of antibiotic treatment and with progress notes to determine any relationship. Cause of the peritonitis was noted.

Complications reported were limited to those directly attributable to operative treatment or postoperative abdominal infections. Postoperative abscesses, fistulas, wound infections, wound dehiscences, eviscerations, and prolonged drainage were recorded. Indirect complications such as atelectasis, pulmonary embolus, nonfatal myocardial infarction, stroke, pneumonia, etc., although possibly directly related to an operation, were excluded as being due not to the specific diseases being studied or to modifications of the antibiotic treatment, but to operative procedures in general.

After collection of all data, patients were divided into categories based on *empiric* antibiotic treatment such as triple-drug therapy, double broad-spectrum combinations, or single broad-spectrum treatment. Empiric antibiotic therapy was defined as that regimen initiated at the time of operative intervention, and before the availability of any culture data.

A second classification design compared empiric antibiotic choice and the culture results, which then permitted patients to be divided into five groups. An "A" classification indicated the antibiotics given were excessive for culture and sensitivity results, for example, ampicillin was used in treatment but no enterococcus was cultured. A "B" classification indicated the antibiotics used adequately covered cultured bacteria as per the sensitivity results. A "C" classification indicated the antibiotic choice was inadequate for the cultured bacteria based on sensitivity results, for example, *Bacteroides fragilis* was cultured but the patient received no anaerobic coverage. A "D" classification indicated the culture data were inadequate to classify the antibiotic choice, or the patients had no cultures taken. An "E" classification indicated an antibiotic choice that was redundant, for example, treating an *Escherichia coli* culture with both gentamicin and amikacin.

A third classification was established to divide the patients according to the surgeon's response to culture results. We believe that culture results were used to modify patient care if additional drug or drugs were added to an existing regimen to deal with culture results and sensitivities; deletion of drug or drugs from an existing regimen occurred; an entirely different antibiotic regimen was started; or all antibiotics were stopped in response to cultures, as in a no-growth culture. The patients were thus divided into three groups. Group 1 consisted of patients whose antibiotics were not changed after culture results returned. Group 2 consisted of patients whose antibiotic regimen was added to, deleted from, or whose regimen was changed in such a way that the organisms cultured were covered by the regimen. Group 3 patients had their antibiotic regimens changed but the change was inappropriate as judged by the sensitivity results. It should be emphasized that the interpretation of the antibiotic selection as being "appropriate" or "inappropriate" is strictly an interpretation with respect to the culture results obtained. It does not reflect any prejudice that the authors might hold for appropriateness of care.

Results

One thousand eight hundred thirty-one charts were reviewed. The charts of 480 patients met our criteria for inclusion in the study. The average age was 44.1 years, with a range from 1.5 to 99 years. There were 180 females and 300 males. The median duration of symptoms, before hospitalization, for the acute process that resulted in peritonitis and operation was 3.3 days. The average was 2.3 days for patients with a perforated appendix, and 5.5 days for patients with a perforated colonic diverticulum. In all cases, a well-documented peritonitis existed at the time of operation.

Among the 480 peritonitis cases, 281 were secondary to perforation of the appendix (Table 1). An additional 130 patients had perforated colonic lesions from either diverticular disease or other colonic pathology (*e.g.*, perforated colon carcinoma, cecal perforation from distention, etc.). Among the "other cases identified in Table 1 were perforations of the small intestine, perforated pseudocysts, perforated necrotic intestine, (thought to be from other than vascular occlusion), perforated duodenum, and delayed recognition of stab wounds involving the intestine.

The morbidity and mortality rates by anatomic site of the source of the peritonitis are detailed in Table 2. The mortality rate for all 480 patients was 6%. Intra-abdominal abscess rate was 10%. Wound dehiscence/evisceration occurred in nearly 4% of all patients.

Only 326 patients (68%) had cultures taken intraoperatively. Twenty-three of these were reported as no growth (6.7%), and nine culture specimens were "lost" before culture. Seven hundred eighty-one bacterial isolates were cultured from the remaining 294 cultures (2.6 bacterial isolates per culture). The most common bacteria identified were *E. coli* and *B. fragilis* (Table 3). The identified bacterial species were consistent with other reports of peritonitis cultures in the literature.[3-5]

For empiric antibiotic choice, a triple drug combination was chosen in 92 patients (19.2%), a double drug combination was chosen in 79 (16.7%), and 307 patients (63.1%) were treated with a single antibiotic (Table 4). Of

TABLE 1. *Descriptive Information of Anatomic Site of Operation That Resulted in Peritonitis in 480 Patients*

Anatomic Site	Average Age (yr)	Length of Operation (min)	Length of Stay (days)
Perforated appendix (n = 281)	33.2 ± 1.4	70 ± 1.93	8.4 ± 0.4
Perforated diverticulum (n = 98)	58.8 ± 1.5	150 ± 6.4	14.2 ± 1.3
Other perforated colon (n = 32)	61.3 ± 3.7	155 ± 12.7	30.9 ± 7.5
Perforated ulcer (n = 26)	61.7 ± 4.1	95 ± 8.1	11.3 ± 1.8
Perforated gallbladder (n = 13)	70.5 ± 4.7	105 ± 11.9	21.7 ± 6.0
All other (n = 30)	53.1 ± 4.9	117 ± 12.3	20.6 ± 3.49
Mean (n = 480)	44.1 ± 1.2	97 ± 2.7	12.4 ± 0.7

Mean ± SEM.

TABLE 2. *Morbidity and Mortality Rates by Anatomic Site*

	Wound Morbidity		Intra-abdominal		
Anatomic Site	Infection	Dehiscence/Evisceration	Abscess	Reoperation	Death
Perforated appendix (281)	28 (10%)	5 (1.8%)	30 (10.7%)	40 (14.2%)	3 (1.1%)
Perforated diverticulum (98)	15 (15.3%)	8 (8.2%)	5 (5.1%)	9 (9.2%)	6 (6.2%)
Other perforated colon (32)	8 (25%)	2 (6.3%)	9 (28.1%)	5 (15.6%)	7 (21%)
Perforated ulcer (26)	2 (7.7%)	3 (11.5%)	1 (3.8%)	1 (3.8%)	2 (7.7%)
Perforated gallbladder (13)	1 (7.7%)	0	0	1 (7.7%)	1 (7.7%)
All other (30)	10 (33%)	0	4 (13.3%)	4 (13.3%)	10 (33%)
Total (N = 480)	64 (13.3%)	18 (3.8%)	49 (10.2%)	60 (12.5%)	29 (6.0%)

the 307 patients treated empirically with a single drug choice, cefoxitin or ampicillin/sulbactam (Unasyn) was the most frequent. Of the 79 patients who received a combination of two antibiotics, the most frequent choices included gentamicin plus a second drug for anaerobic coverage. Of the 92 patients receiving triple-drug treatment, the combination of ampicillin, gentamicin, and clindamycin or metronidazole was most frequent.

Analysis of patient clinical variables on presentation (Table 5) shows an apparently comparable population for the triple-drug, double-drug, and single-drug groups. The triple-drug group was significantly younger, had a higher percentage of preoperative antibiotics, and was composed of more patients with the milder disease of perforated appendicitis. The double-drug group was older, had fewer patients with appendicitis, and a longer in hospital stay before operation. These differences would seem to favor the triple-drug group with a better than expected outcome, and potentially compromise the outcome of the double-drug group.

Postoperative wound infections developed in 7.6% of the patients in the triple-drug group *versus* 21.5% and 13.6% for the double- and single-drug groups, respectively ($p < 0.01$ between the double- and triple-drug groups). Total wound complications were seen in 18.5% of the triple-drug group, 19.5% in the single-drug group, and in 31.6% of the double-drug group ($p < 0.05$ between both triple- and single-drug treatment over double-drug treatment).

Table 6 also shows a length of stay of 10.7 days for patients treated with a single antibiotic *versus* 15.8 days for double-drug treatment and 15.1 days for the triple-drug group ($p < 0.02$ favoring the single-drug group over the double-drug group). Reoperative rate and postoperative abscess rates were not significantly different between groups.

Mortality rates (Table 6) were compared by chi square analysis and showed a significant difference for the double-drug group (15.2%) *versus* the single-drug group (4.6%), with $p < 0.001$, but no difference for the triple-drug *versus* either of the other groups. Differences between groups are always potentially a consequence of differences between patients in the different groups. This, with the small number of deaths, may not reflect superiority of one treatment regimen over another with respect to mortality rate.

Classification, according to the appropriateness of the empiric antibiotics, determined by comparison of culture data with initial antibiotic choice showed that an excessive regimen (group A) was selected in 77 patients (16%), antibiotics were appropriate (group B) in 180 patients (37.4%) and were inadequate (group C) in 49 patients (10.2%). No culture results (group D) were available for 170 patients (35%). Only five patients fell into group E, where antibiotic therapy was redundant, and these patients were eliminated from further analysis in this category.

Clinical variables at presentation (Table 7) demonstrate an apparent comparability between the groups A, B, C, and D. There was a younger mean age for group A and group B. There was a lower percentage of patients with appendicitis and a higher percentage of patients with colonic perforations in both group D and group C. There was a significantly longer stay in hospital before operation for group C. These differences would favor group A and

TABLE 3. *Bacterial Isolates Cultured From 480 Cases of Acute Peritonitis*

Aerobic	No.	Anaerobic	No.
Escherichia coli	201	*Bacteroides fragilis*	131
Non-enterococcal *Streptococcus*	76	*Peptostreptococcus*	45
Pseudomonas	56	*Clostridium* sp.	17
Klebsiella sp.	50	*Fusobacterium*	15
Enterococcus	31	Gram-negative anaerobes not otherwise speciated	11
Staphylococcus	31		
Mixed enterics not otherwise speciated	22	*Eikenella*	9
		Proprionibacter	4
		Peptococcus	2
Enterobacter	18	Other	8
Candida	12		
Serratia sp.	12		
Citrobacter	10		
Proteus sp.	8		
Corynebacterium	3		
Other	9		
Total	539		242

A total of 781 isolates were identified from 294 cultures that were positive for bacterial growth.

TABLE 4. *Empirical Antibiotic Selections Chosen for the Initial Management of 480 Patients With Acute Bacterial Peritonitis*

Monotherapy (n = 307)	
Cefoxitin	140
Ampicillin/Sulbactam (Unasyn)	64
Cefotaxime	16
Cefotetan	16
Cefazolin	10
Piperacillin	8
Cefoperazone	8
Imipenem	8
Cefuroxime	7
Ceftriaxone	7
Other selections n < 4 for any choice	23
Double antibiotic combination (n = 79)	
Gentamicin + Clindamycin or Metronidazole	19
Gentamicin + Cephalosporin	15
Cephalosporin + Metronidazole	10
Gentamicin + Ampicillin	10
Gentamicin + Ampicillin/Sulbactam	8
Imipenem + Aminoglycoside or Cephalosporin	7
Two Cephalosporins	4
Others	6
Triple antibiotic combination (n = 92)	
Ampicillin + Gentamicin + Clindamycin or Metronidazole	76
Penicillin + Gentamicin + Metronidazole	5
Ampicillin + Gentamicin + Cephalosporin	3
Cephalosporin + Gentamicin + Metronidazole	3
Other	5

group B, but they would adversely affect outcome in group C and more so in group D.

Table 8 shows morbidity and mortality rate indicators for each of the groups classified by antibiotic adequacy. Group B had the shortest length of stay. Group D had a significantly lower total complication rate than group A. Group C had a significantly poorer outcome in all categories with a longer length of stay, a higher rate of wound infection, a higher percentage of postoperative abscesses, a higher rate of reoperation, and a higher rate of total complications.

Three hundred seventy-two of the 480 patients had their antibiotic treatment left unchanged postoperatively. Three hundred twenty-six patients had culture results that could have been used to change their antibiotic treatment. Of these 234 patients (71.7%) did not have their antibiotics changed despite culture results. Forty-one patients (12.5% of patients having cultures) had an appropriate change in treatment, and 67 patients (20.6% of patients having cultures) had their antibiotics changed in an inappropriate manner according to culture results.

From our total population of 480 patients, 108 patients actually had a change in their treatment as a result of the cultures taken at operation (Table 9 shows outcome data of these groups). Sixty-two per cent of these changes were inappropriate, and 38% were appropriate. A positive change in antibiotics, to cover documented culture results, was performed in only 8.8% of the total population.

Analysis of outcome (Table 9) showed a longer length of stay, a higher postoperative abscess rate, a higher reoperative rate, a higher complication rate, and a higher mortality rate for the group having an inappropriate change in therapy, over leaving the antibiotics alone. There was also a poorer outcome for the appropriate change over no change when the rates of abscess formation were compared.

A comparison of outcome for the group "C" patients that had their antibiotics changed appropriately after operation, *versus* those whose antibiotics were left alone or changed inappropriately, showed no difference (Table 10).

Discussion

Since the demonstration by Pawlowsky in 1887[5] of the microbial basis for peritonitis, surgeons have been looking for the chemotherapeutic means to treat this disease regardless of cause. Dr. Paul Ehrlich searched for a *"therapia sterilisans magna"* that would be so effective that "the administration of a single large dose would bring about the selective mass destruction of all bacteria within the

TABLE 5. *Comparison of Perioperative Clinical Variables Among Patient Groups Receiving Either Single, Double, or Triple Antibiotics*

Variable	Single (S) n = 307	Double (Do) n = 79	Triple (T) n = 92
Mean age*	46.1 yr (±1.3)	50.8 yr (±2.8)	31.2 yr (±2.9)
Percent appendicitis†	58%	49%	68%
Percent colon perforation	27.0%	26.6%	25.1%
Preoperative antibiotics‡	254 (82.7%)	69 (87.3%)	85 (92.4%)
Delayed primary closure§	127 (41.4%)	44 (55.7%)	54 (58.7%)
Duration of illness before hospitalization (days)	3.0 ± 0.3	3.9 ± 1.3	3.7 ± 0.9
Preoperative stay before operation (hr)‖	27.4 ± 1.2	36.2 ± 3.2	28.4 ± 2.3
Length of operation (min)¶	94.1 ± 5	94.9 ± 3.4	110.7 ± 6.7
No. of bacteria per culture	1.7	1.7	1.9

* Two-tailed paired t test gives $p < 0.0001$ for S *vs.* T and Do *vs.* T.

† Chi square analysis gives $p < 0.02$ for Do *vs.* T.

‡ Chi square analysis gives $p < 0.02$ for S *vs.* T.

§ Chi square analysis gives $p < 0.05$ for S *vs.* Do and $p < 0.01$ for S *vs.* T.

‖ Two-tailed paired t test gives $p < 0.01$ for Do *vs.* S and $p < 0.05$ for Do *vs.* T.

¶ Two-tailed paired t test gives $p < 0.03$ for S *vs.* T.

TABLE 6. *Comparison of Outcome Variables Among Patient Groups Receiving Either Single, Double, or Triple Antibiotics*

	Antibiotic Choice		
Variable	Single (S) n = 307	Double (Do) n = 79	Triple (T) n = 92
Length of stay (days)*	10.7	15.8	15.1
Wound infection†	42 (13.6%)	17 (21.5%)	7 (7.6%)
Abdominal abscess	34 (11.1%)	11 (13.9%)	10 (10.9%)
Reoperation	45 (14.7%)	13 (16.5%)	16 (17.4%)
Total complications‡	60 (19.5%)	25 (31.6%)	17 (18.5%)
Deaths§	14 (4.6%)	12 (15.2%)	6 (6.5%)

* Two-tailed paired Student's t test gives $p < 0.02$ for S *vs.* Do.
† Chi square analysis gives $p < 0.01$ for Do *vs.* T.
‡ Chi square analysis gives $p < 0.05$ for Do *vs.* T and Do *vs.* S.
§ Chi square analysis gives $p < 0.01$ for S *vs.* Do.

body and result in the immediate recovery of the patient from the state of disease produced by their presence."[4]

The traditional dictum has always been that if one could surgically correct the underlying pathology, and isolate and treat the causative organism, an optimum result could be achieved. Accordingly culturing and obtaining the antibiotic sensitivity of the organisms isolated from the peritoneal cavity have become mandates of patient care. The further assumption has been that the modification of a patient's antibiotic regimen to cover deficiencies identified by culture results is also necessary. With the demonstration by multiple authors[5-11] of the consistent nature of bacterial isolates from patients with peritonitis, and the general use of broad-spectrum antibiotics, the need for operative cultures has been questioned.[1,2] We performed this study to answer the following questions: (1) Is there any advantage to using more than a single broad-spectrum antibiotic? (2) Does the accuracy of matching empiric antibiotic treatment to subsequent cultured organisms predict outcome? (3) Does adjusting the antibiotic choice based on culture data affect outcome?

Many clinicians believe that the use of triple-drug therapy is the best way to "completely cover" the bacterial flora of peritonitis, and that this coverage gives the patient the best chance of recovery. David et al. in 1982,[12] in a group of 300 pediatric patients with gangrenous and perforated appendicitis, showed a marked decrease in wound infection rate, postoperative abscess rate, and a shorter length of stay in those patients treated with ampicillin, gentamicin, and clindamycin. His control group consisted of patients treated (1) without antibiotics, (2) with ampicillin alone, (3) with gentamicin alone, or (4) with the combination of ampicillin and gentamicin. In a prospective randomized trail of pediatric patients with appendicitis, King et al.[13] found fewer "treatment failures" in the group treated with ampicillin, gentamicin, and clindamycin, *versus* those treated with ampicillin and gentamicin. Both these studies, although quoted often in defense of triple-drug therapy, simply confirmed the results of Louie et al.,[14] who showed a benefit in treating the anaerobic component of peritonitis by adding clindamycin.

There are studies that show an equal or better outcome for patients treated with single-drug therapy *versus* multiple drug therapy. In a recent study of patients with peritonitis and sepsis, Huizinga et al.[15] demonstrated a satisfactory response in 82% of patients given cefotetan *versus* 65% of patients treated with ampicillin, gentamicin, and

TABLE 7. *Comparison of Perioperative Clinical Variables Among Patient Groups Receiving Either Excessive, Adequate, Inadequate, or Nonclassifiable Antibiotic Regimens*

	Antibiotic Choice			
Variable	Group A n = 77	Group B n = 180	Group C n = 49	Group D n = 170
Average age*	36.6 ± 3.1	42.6 ± 1.9	45.7 ± 3.4	48.6 ± 1.8
Percent appendix†	67.5%	68.9%	49%	47.6%
Percent colon perforation‡	16.9%	21.7%	34.7%	32.4%
Preoperative antibiotics	70 (90.9%)	147 (81.7%)	43 (87.8%)	147 (85.9%)
Delayed primary closure§	40 (51.9%)	82 (45.6%)	20 (40.8%)	48 (28.2%)
Duration of illness before hospitalization (days)	2.8 ± 0.4	2.6 ± 0.3	4.5 ± 1.4	3.5 ± 0.5
Preoperative hospital stay before operation (hr)‖	29.9 ± 2.5	26.9 ± 1.5	39.9 ± 4.3	27.6 ± 1.6
Length of operation (min)¶	102 ± 7	85.1 ± 4	104.8 ± 10	106.0 ± 5
No. of bacteria per culture	2.2	2.4	2.8	NA

* Two-tailed paired t test gives $p < 0.001$ for A *vs.* D and $p < 0.02$ for B *vs.* D.
† Chi square analysis gives $p < 0.05$ for A *vs.* C, $p < 0.01$ for A *vs.* D, $p < 0.01$ for B *vs.* C, and $p < 0.001$ for B *vs.* D.
‡ Chi square analysis gives $p < 0.05$ for A *vs.* C, $p < 0.01$ for A *vs.* D, and $p < 0.02$ for B *vs.* D.
§ Chi square analysis gives $p < 0.001$ for A *vs.* D and $p < 0.01$ for B *vs.* D.
‖ Two-tailed paired t test gives $p < 0.05$ for A *vs.* C, $p < 0.05$ for B *vs.* C, and $p < 0.01$ for C *vs.* D.
¶ Two-tailed paired t test gives $p < 0.05$ for A *vs.* B and $p < 0.001$ for B *vs.* D.

TABLE 8. *Comparison of Outcome Variables Among Patient Groups Receiving Either Excessive, Adequate, Inadequate, or Nonclassifiable Antibiotic Regimens*

	Antibiotic Choice			
Variable	Group A n = 77	Group B n = 180	Group C n = 49	Group D n = 170
Length of stay (days)*	14.0	9.6	18.5	13.0
Wound infection†	11 (14.2%)	26 (14.4%)	13 (26.5%)	16 (9.4%)
Abscess‡	5 (6.5%)	19 (10.5%)	17 (34.7%)	13 (7.6%)
Reoperation§	9 (11.7%)	25 (13.9%)	18 (36.7%)	23 (13.5%)
Total complications‖	23 (29.9%)	34 (18.9%)	25 (51.0%)	24 (14.1%)
Death	5 (6.5%)	10 (5.6%)	6 (12.2%)	8 (4.7%)

* Two-tailed paired t test gives $p < 0.02$ for B *vs.* C and $p < 0.05$ for B *vs.* D.
† Chi square analysis gives $p < 0.05$ for B *vs.* C and $p < 0.01$ for D *vs.* C.
‡ Chi square analysis gives $p < 0.001$ for all three combinations, A *vs.* C, B *vs.* C, and D *vs.* C.
§ Chi square analysis gives $p < 0.001$ for all three combinations, A *vs.* C, B *vs.* C, and D *vs.* C.
‖ Chi square analysis gives $p < 0.02$ for A *vs.* C, $p < 0.01$ for A *vs.* D, and $p < 0.001$ for both B *vs.* C and D *vs.* C.

metronidazole. We are not aware of studies showing that the addition of ampicillin to the "gold standard" of an aminoglycoside plus anaerobic coverage will improve efficacy for patients with peritonitis. Ampicillin may increase the incidence of diarrhea.[16]

There are many studies showing that the outcome of patients with peritonitis treated with double-drug regimens is poorer, or equivalent to, that of patients treated with a single broad-spectrum antibiotic.[17-20] As Solomkin and co-workers[21] noted, "Published reports of antibiotic comparisons have largely failed to demonstrate noteworthy differences in clinical outcome despite markedly disparate antibiotic sensitivity spectra."[21]

Our data support the effectiveness of single-drug therapy in peritonitis. The groups treated with the triple- or the double-drug regimens had a higher mortality rate (7% and 15% *vs.* 4.6%), and a longer length of stay (Table 6). The triple-drug group had a lower postoperative wound infection rate, but this correlated with a significantly ($p < 01$) higher frequency of selecting delayed primary closure at the initial operation. Although one might argue that combination therapy patients had more severe disease, there was not a demonstrable difference in the distribution of disease, the number of or type of concurrent diseases, or the severity of symptoms at presentation. In fact the patients treated with triple-drug therapy were younger, more often had peritonitis due to appendicitis, and had fewer bacterial species per culture. All of these parameters would tend to favor a better outcome among patients treated with triple-drug therapy.

It appears that more is not necessarily better when treating patients with bacterial peritonitis, and that it is not a requirement to eradicate every organism to optimize results. Killing the "nonpathogenic" normal bowel flora with excess antibiotics may in fact be detrimental to the patient.

Clinical experience has shown that a surgeon's choice of antibiotics is based on his expectation of bacteria likely to be present. Many surgeons doubt the accuracy of culture results and use this as reasoning to continue additional coverage in the face of negative culture results for a particular organism. The concept that "excess" antibiotic treatment can be anything but good is ignored. Our data show that the outcome of the patient is affected by the choice and adequacy of the empiric antibiotic or antibiotics used, and that adequate treatment is clearly better than excessive or inadequate initial treatment.

Of specific interest is the persistently poor outcome for the "C" group or the inadequate initial treatment group. The higher reoperative rate, abscess rate, wound infection rate, complication rate, and mortality rate are suggestive

TABLE 9. *Comparison of Outcome Variables Among Patient Groups Having Either no Change of Antibiotics After Culture Data Available, Having an Appropriate Change After Data Available, or Having an Inappropriate Change After Data Available*

	Antibiotic Choice		
Variable	Group 1 n = 372	Group 2 n = 41	Group 3 n = 67
Length of stay (days)*	10.9	14.8	19.0
Wound infection	49 (13.2%)	6 (14.6%)	11 (16.4%)
Total complications†	69 (18.5%)	9 (22.0%)	23 (34.3%)
Abscess‡	28 (7.5%)	8 (19.5%)	16 (23.9%)
Reoperation§	45 (12.1%)	9 (22.0%)	21 (31.3%)
Death‖	20 (5.4%)	3 (7.3%)	9 (13.5%)

* Two-tailed paired t test gives $p < 0.008$ for 1 *vs.* 3.
† Chi square analysis shows $p < 0.01$ for 1 *vs.* 3.
‡ Chi square analysis shows $p < 0.01$ for 1 *vs.* 2 and $p < 0.0001$ for 1 *vs.* 3.
§ Chi square analysis shows $p < 0.0001$ for 1 *vs.* 3.
‖ Chi square analysis shows $p < 0.02$ for 1 *vs.* 3.

TABLE 10. *Outcome Variables for Patients Having Either Inadequate Antibiotic Treatment Initially With no Change in Therapy Plus Inadequate Initial Antibiotic Treatment With Inappropriate Change* Versus *Inadequate Initial Antibiotic Treatment With an Appropriate Change*

Group	N	Length of Stay	Reoperation	Abscess	Wound Infection	Total Complications	Death
C1 + C3	36	18.8	15 (42%)	12 (33%)	11 (31%)	16 (44%)	3 (8%)
C2	13	17.7	3 (23%)	3 (23%)	2 (15%)	4 (31%)	3 (23%)
p		NS	NS	NS	NS	NS	NS

that if a patient's empiric antibiotic treatment is inadequate, the outcome seems to be worse regardless of the organisms isolated. If one changes the antibiotic regimen after operation to an antibiotic regimen that sufficiently covers the organism grown on culture, an improvement in outcome was not demonstrated (Table 10). It appears that by the time patients have received their empiric antibiotics, had their operative procedures, been irrigated, and drained if appropriate, the outcome of their peritonitis has been determined. By the time cultures taken at operation have returned, our ability to favorably influence this outcome with antibiotic treatment has been lost, and any manipulation of antibiotics is futile. It may be hazardous to consider shortcuts in empiric antibiotic treatment, with the attitude that postoperative change according to culture results will compensate for initial undertreatment.

Surprisingly the group not having culture results did as well as those treated adequately, or accurately, by culture results in all respects except for the length of stay. The thesis that culture result data rarely contribute in a useful way to the patient's postoperative outcome is supported by our data.

Our study demonstrates that a surgeon's selection of empiric antibiotics has a low probability of being changed after the actual culture information is received. The actual culture results are typically ignored in the postoperative period. The reasons for this are (1) lack of physician confidence in the accuracy of the clinical microbiologic laboratory to identify all pathogens present in the exudate, (2) lack of confidence in anaerobic sensitivity data, and (3) current recommendations of antibiotic coverage by "authorities" in peritonitis management. This supports the current surgical practice of treating for the expected bacteria usually present rather than how many of these bacteria the laboratory can isolate. This approach was demonstrated to be as good as, or better than, treating a patient according to the culture results in our study.

In conclusion obtaining cultures at the initial operation for peritonitis may not be justified. There is an advantage for using single-drug therapy rather than triple- or double-drug therapy, assuming that comprehensive aerobic and anaerobic coverage for anticipated pathogens is present. There is a disadvantage to initial antibiotic undertreatment.

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