

Current Status

LEE E. SMITH, M.D., *Editor*

With the rapid change of technology and increasing volumes of information, review articles are increasingly valuable. In an effort to provide this service for our readers, we solicit and publish review articles which summarize the current status of diagnosis and treatment of colonic disease.

Preoperative Bowel Preparation A Survey of Colon and Rectal Surgeons

JULIO A. SOLLA, M.D., DAVID A. ROTHENBERGER, M.D.

Solla JA, Rothenberger DA. Preoperative bowel preparation: a survey of colon and rectal surgeons. *Dis Colon Rectum* 1990;33:154-159.

A survey of 500 clinically active, board-certified colon and rectal surgeons in the United States and Canada was conducted to obtain data regarding current methods of bowel preparation for elective colorectal surgery. A review of recent publications on preoperative bowel preparation was used to compare the current literature recommendations with the actual practice among the group surveyed. Responses were received from 352 of 500 colorectal surgeons to whom questionnaires were sent (70 percent response rate). All respondents used a mechanical preparation and some form of antibiotics. The favorite antibiotic regimen was oral antimicrobials combined with systemic antibiotics (88 percent). Concomitant administration of oral neomycin-erythromycin base and a systemic second generation cephalosporin active against both anaerobic and aerobic colonic bacteria, together with oral polyethylene glycol electrolyte mechanical colonic cleansing, was the most popular method of preoperative bowel preparation (58 percent). The second most frequent method of mechanical bowel cleansing consisted of conventional enemas, dietary restrictions, and cathartic preparations (36 percent). Mannitol solution (5 percent), and whole-gut irrigation per nasogastric tube (1 percent) were the least popular methods of mechanical bowel cleansing. The literature supports the current methods of preoperative bowel preparation used by the vast majority of surgeons surveyed. [Key words: Bowel preparation, colonic, cleansing; Prophylactic antibiotics]

PREOPERATIVE BOWEL PREPARATION has become almost a ritual among surgeons performing elective colorectal surgery.¹ Reducing the risk of postoperative

*From the Department of Surgery,
Division of Colon and Rectal Surgery,
University of Minnesota,
Minneapolis, Minnesota*

infection is the goal, and this objective generally is achieved with a combination of mechanical bowel cleansing and prophylactic antibiotic administration. The ideal method of bowel cleansing is one that is safe, effective, efficient to administer, inexpensive, and well tolerated by the patient. There is still little agreement as to the best method of mechanical bowel preparation. Numerous controlled studies conducted over the last 20 years have demonstrated unequivocally the value of antibiotic prophylaxis in elective colorectal surgery. Controversy persists regarding the preferred route of administration, the ideal antibiotic(s), and the efficacy and necessity of using a combination of both oral and systemic antibiotics. We conducted a survey among clinically active, board-certified, colon and rectal surgeons in the United States and Canada to obtain data regarding current clinical practices in preparing patients for elective colorectal surgery. An extensive review of the pertinent literature was used to compare the most current recommendations with the current clinical practice among the group surveyed.

Methods

Five hundred clinically active, board-certified, colon and rectal surgeons were sent questionnaires requesting

Poster presentation at the meeting of the American Society of Colon and Rectal Surgeons, Toronto, Canada, June 11 to 16, 1989.

Address reprint requests to Dr. Rothenberger, Department of Surgery, Colon and Rectal Surgery, University of Minnesota, Box 327, 420 Delaware Street S.E., Minneapolis, Minnesota 55455.

TABLE 1. Preferred Mechanical Colon Preparation Used by Surgeons Responding to Our Survey

Preferred Mechanical Colon Preparation	Surgeons (Percent) Number
PEG	206 (58)
Traditional	126 (36)
Mannitol	17 (5)
Whole-gut lavage	3 (1)
TOTAL	352 (100)

information regarding their current methods of bowel preparation for elective colorectal operations. The names of surgeons chosen for survey were obtained from the Directory of Certified Surgeons of the American Board of Colon and Rectal Surgery. The survey was limited to nonretired members in the United States and Canada. The survey questionnaire was designed to elicit a response to these issues: 1) method of mechanical bowel cleansing—a) conventional cathartic and enema preparation, b) mannitol solution preparation, c) whole-gut irrigation per nasogastric tube, d) oral polyethelene glycol (PEG) electrolyte lavage, or e) other; 2) use of orally administered preoperative antibiotics—a) neomycin, b) erythromycin base, c) metronidazole, d) none, e) other, or f) a combination of oral antibiotics; 3) use of systemically administered antibiotics—a) first or second generation cephalosporin, b) clindamycin, c) metronidazole, d) aminoglycoside, e) synthetic penicillin, f) none, g) other, or h) a combination of intravenous antibiotics. Questionnaires were sent in four mailings during February 1988. All responses were received within three months from the last mailing.

Results

Responses were received from 352 of 500 colon and rectal surgeons to whom questionnaires were sent (response rate of 70 percent).

All surgeons in our survey used a preoperative mechanical cleansing of the colon and some form of oral and/or systemic antibiotics. The preferred mechanical cleansing regimen was PEG (206, 58 percent), cathartics and enemas (126, 36 percent), mannitol (17, 5 percent), and whole gut lavage (3, 1 percent) (Table 1).

One hundred and ninety of the 206 surgeons (92 percent) in the PEG group used an oral aminoglycoside (neomycin, kanamycin, or gentamicin) in combination with either oral erythromycin base (156 of 190, 82 percent), oral metronidazole (33 of 190, 17 percent), or oral tetracycline (1 of 190, 0.5 percent) (Table 2). The favorite oral antibiotic regimen was neomycin and erythromycin base. Two surgeons used oral neomycin alone and two used oral metronidazole alone. Twelve surgeons (6 percent) in the PEG group did not use oral antibiotics as part of their preoperative bowel preparation and used only systemic antibiotics. Systemic antibiotic(s) were used by 202 of the 206 surgeons (98 percent) in the PEG mechanical cleansing group and 4 surgeons (2 percent) used only oral antimicrobials without systemic antibiotics. One hundred eighty-six of 206 surgeons (90 percent) in the PEG group used systemic antibiotics in combination with two oral antimicrobials as part of their preoperative bowel preparation. The most common systemic antibiotics used in the PEG group were second generation cephalosporins active against both anaerobic and aerobic bacteria (163 of 206, 79 percent).

One hundred twenty-six of 352 surgeons (36 percent) used the traditional one- to three-day preparation, which included dietary restrictions, enemas, and cathartics. One hundred eleven of 126 surgeons (88 percent) used oral neomycin in combination with either oral erythromycin base (104 of 111, 93 percent), oral metronidazole (6 of 11, 5 percent), or oral clindamycin

TABLE 2. Antibiotics Used with the Different Types of Mechanical Colon Preparation Used by Surgeons Responding to our Survey

	Type of Mechanical Preparation			
	PEG	Traditional	Mannitol	Whole-gut lavage
Number of Surgeons	206	126	17	3
Oral Antibiotic(s)				
None	12 (6%)	13 (10%)	4 (24)	—
Aerobic coverage only	2 (1%)	1	—	—
Anaerobic coverage only	2 (1%)	1	—	—
Aerobic and anaerobic	190 (92%)	111 (88%)	13 (76%)	3 (100%)
Systemic antibiotic(s)				
None	4 (2%)	8 (6%)	—	—
1st generation cephalosporin	10 (5%)	14 (11%)	—	—
2nd generation cephalosporin	163 (79%)	83 (66%)	12 (71%)	3 (100%)
Other	29 (14%)	21 (17%)	5 (29%)	—
Systemic antibiotic(s) plus oral antibiotics for both aerobic and anaerobic coverage	186 (90%)	103 (82%)	13 (76%)	3 (100%)

(1 of 111, 1 percent). One surgeon used oral metronidazole alone, and another used oral neomycin alone. Thirteen surgeons in the conventional group did not use oral antibiotics as part of their preoperative bowel preparation (13 of 126, 10 percent) and only used systemic antibiotics. One hundred eighteen of the 126 surgeons (94 percent) using the traditional mechanical preparation used systemic antibiotics, and eight surgeons (6 percent) used only oral antimicrobials without systemic antibiotics. One hundred three of 126 surgeons (82 percent) using the traditional mechanical preparation used systemic antibiotics in combination with two oral antimicrobials as part of their preoperative bowel preparation. The most common systemic antibiotics used in the conventional group were second generation cephalosporins active against both anaerobic and aerobic bacteria (83 of 126, 66 percent).

Seventeen of 352 surgeons (5 percent) used mannitol solution as their method of mechanical bowel cleansing. All 17 surgeons used systemic antibiotics. Thirteen of 17 surgeons (76 percent) in the mannitol group used both systemic and two oral antibiotics as part of their preoperative bowel preparation. Four surgeons used no oral antibiotics. The favorite regimen in the mannitol group was oral neomycin-erythromycin base, together with a second generation cephalosporin active against both anaerobic and aerobic bacteria.

Three of 352 surgeons (1 percent) surveyed used whole-gut irrigation per nasogastric tube as their method of mechanical bowel cleansing. All three surgeons used oral neomycin-erythromycin base in combination with a systemic second generation cephalosporin active against both anaerobic and aerobic bacteria.

Discussion

Eighty-eight percent of colon and rectal surgeons surveyed used oral antibiotics combined with systemic antibiotics in addition to mechanical bowel cleansing. The most frequently used regimen of preoperative bowel preparation was the simultaneous administration of oral neomycin-erythromycin base, a systemic second generation cephalosporin, and oral PEG solution mechanical bowel cleansing. All of the surgeons responding to our survey used some form of antibiotics as part of their preoperative bowel preparation. This is in contrast to prior surveys taken during the last decade that indicated that between 13 and 16 percent of surgeons did not use prophylactic antibiotics for colon operations.^{2,3} The question of whether to use antibiotics for patients undergoing colorectal operations seems resolved—antibiotic prophylaxis of some sort is now considered obligatory in this type of surgery. The question is what drug(s), what dose, what duration,

and what spectrum of bacterial coverage is ideal? Current controversies regarding bowel preparation focus on: 1) the ideal mechanical bowel-cleansing method, 2) the ideal systemic antibiotics, 3) the ideal oral antibiotic(s), and 4) whether a combination of oral and systemic antibiotics is most effective or whether one or the other antibiotic alone is preferred.

The ideal mechanical bowel-cleansing method should be safe, rapid, inexpensive, well tolerated by the patient, easy to use at home or in the hospital, and effective. Traditionally this has been achieved by dietary restrictions, repeated use of enemas, and cathartics preoperatively. Despite the obvious disadvantages of a prolonged preparation often requiring preoperative hospitalization, the patient's and nurse's aversion to repeat enemas, the potential risk of dehydration, and aggravation of malnutrition, this method, until recently, has been the primary method utilized.^{1,2,4,5} We were surprised that only 126 of 352 surgeons (36 percent) responding to our survey still used the traditional method of bowel cleansing.

Whole-gut irrigation consists of infusion of large quantities of saline solution through a nasogastric tube. This technique of mechanical bowel cleansing was first introduced by Hewitt *et al.* in 1973.⁶ Whole-gut lavage has been demonstrated to be more rapid and as effective as the conventional cathartic-enema regimen in cleansing the bowel of gross feces.⁷ The major problem associated with high-volume electrolyte solution lavage is retention of both water and electrolytes by patients, particularly those with marginal cardiac or renal functions. The nasogastric tube required to administer the whole-gut lavage is also poorly tolerated by a large number of patients.^{8,9} Not surprisingly, only three of the 352 colon and rectal surgeons (1 percent) responding to our survey used whole-gut irrigation per nasogastric tube as part of their preoperative bowel preparation.

Mannitol solution mechanical bowel cleansing works as an osmotic cathartic that is not absorbed from the gastrointestinal tract and can attract fluid from the circulation into the bowel lumen.

The advocates of mannitol note that it is better tolerated by patients because the volume required for thorough cleansing is small, it is more palatable to drink than oral PEG solution, and it is a more comfortable regimen than whole-gut irrigation because the patient does not have to submit to nasogastric intubation or sit continuously on a commode. Unfortunately, two problems have been associated with ingestion of mannitol, thus damaging its reputation. The small amount of mannitol that remains in the colon acts as a bacterial nutrient, facilitating the growth of *Escherichia coli*.¹⁰ Despite preoperative systemic antibiotic prophylaxis, the incidence of sepsis after

mannitol preparation has been as high as 40 percent.¹¹ The addition of combination oral and systemic antibiotics to the mannitol bowel preparation has dramatically lowered the incidence of postoperative infections.¹² Another theoretical disadvantage of mannitol is that it can form explosive gases with the colon because it is metabolized by *E. coli*.¹³ Although these problems are theoretical and rare, few surgeons in the United States and Canada use mannitol. Only 17 of the 352 surgeons (5 percent) responding to our survey still use mannitol solution as part of their preoperative bowel preparation.

Oral PEG electrolyte lavage seems to meet most of the demands of the ideal mechanical bowel preparation. It is a safe, inexpensive, rapid, one-day mechanical bowel preparation for colorectal surgery. A nasogastric tube is almost never required, minimal or no nursing care is needed, and patients are able to provide for themselves both in and out of the hospital. PEG is not metabolized by colonic micro-organisms and is almost inert with respect to water retention, sodium absorption, and intestinal secretion.¹⁴ Oral PEG electrolyte lavage has been demonstrated to be superior to the conventional mechanical bowel cleansing method,⁸ and equal to whole-gut irrigation in providing good colonic cleansing.¹⁵⁻¹⁷ Oral PEG electrolyte lavage is an attractive, effective preoperative bowel cleansing method for colorectal surgery and has become the preferred method of mechanical preparation for colorectal surgeons (206 of 352, 58 percent) responding to the survey.

Whether systemic antibiotic prophylaxis reduces the incidence of infection after colorectal surgery is no longer a major question.² Three hundred forty of the 352 surgeons (97 percent) in our survey used systemic antibiotics. The question now is what type or class of systemic antibiotic, what dose, and what duration are best for elective colon and rectal surgery. In the past decade, recognition of the important role that anaerobic bacteria play in causing infection after colorectal operations has led to a significant change with regard to the choice of systemic antibiotics. Most recent clinical trials indicate that an antibiotic active against both anaerobic and aerobic organisms, both of which inhabit the colon, is necessary to reduce the incidence of septic complications after colorectal surgery.^{4,18-24} Although it has been shown that agents such as the first generation cephalosporins, active only against facultative anaerobic organisms, have been effective,¹⁸ most recent studies indicate that aerobes and obligate anaerobes act synergistically to produce postoperative sepsis.^{19,22} Obligate anaerobes are principally responsible for postoperative infections after colorectal surgery, and first generation cephalosporins are inactive against obligate

anaerobes. It seems reasonable that an appropriate prophylactic systemic antibiotic regimen for colorectal surgery should be directed against aerobic and both obligate and facultative anaerobic organisms. Not surprisingly 261 of 352 surgeons (74 percent) responding to our survey used a second generation cephalosporin active against both aerobic and anaerobic bacteria.

There have been few current topics in surgery more controversial than the role of intestinal antiseptics in the preparation of patients for bowel surgery. It has been difficult to demonstrate that a combination of oral and systemic antibiotics is better than either one alone. Since both oral and systemically administered antibiotics have both been demonstrated to be efficacious, a question arises about which route of administration should be preferred, and if there is an advantage to using a combination of both. Three prospective, randomized studies²⁵⁻²⁷ have shown a further reduction in the risk of infection with the addition of a systemic cephalosporin to oral neomycin-erythromycin base. The data from these three studies were statistically significant. Other clinical studies also have shown the advantages of the addition of a systemic antibiotic to oral antibiotics in lowering the incidence of infection after colorectal surgery.²⁸⁻³⁴ The criticism of these studies is that they failed to use common systemic antibiotics in both groups of patients, thus making the data difficult to interpret. One of the best-known and strongest advocates of the use of oral antibiotic preparations alone admits that the optimal regimen of antibiotic bowel preparation remains to be determined.³⁵ Condon *et al.*^{36,37} in a five-year multicenter controlled trial, found that the infection rate was higher in patients receiving a combination of oral and systemic antibiotics. They concluded that the difference was not statistically significant and therefore there seemed to be no discernible benefit from adding systemic antibiotics when performing elective colorectal surgery if appropriate mechanical cleansing and oral antibiotic therapy were employed. Condon,³⁸ however now uses a systemic second generation cephalosporin in addition to oral neomycin-erythromycin base as part of the preoperative bowel preparation for low anterior resections. Condon acknowledged that the standard surgical practice across the country is to use oral antibiotics and to supplement them with systemic antibiotics, and calls this practice the "belt and suspenders" approach, but believes that the incidence of serious complications of short-term systemic cephalosporins is low. Clearly the evidence of this important issue is still contradictory. It is certainly clear that the vast majority of surgeons in our survey believe that the advantages of the combination of systemic and oral antibiotic prophylaxis outweigh their disadvantages. Only 12 of the 352 surgeons (3 percent)

in our survey used oral antibiotic prophylaxis alone without systemic antibiotics. Twenty-nine of the 352 surgeons (8 percent) used systemic antibiotics alone without oral antibiotics. Advocates of either one of the single antibiotic regimens will always find literature to support their views, but numerous and more recent studies are showing a shift toward further improvement of infection rates with combination systemic and oral antibiotic prophylaxis.^{4,25,32,39} Oral antibiotic prophylaxis combined with systemic antibiotics seems to lower the incidence of infections overall compared with the use of only oral antibiotics in elective colon and rectal surgery.^{25-34,40,41}

Our survey and review of the literature suggest that the ideal and most popular method of preoperative bowel preparation for colorectal surgery is polyethylene glycol mechanical bowel cleansing, followed by a combination of oral neomycin-erythromycin base and a systemic second generation cephalosporin active against both anaerobic and aerobic bacteria. Recent literature supports the current method of preoperative bowel preparation used by the majority of clinically active colon and rectal surgeons in our survey. Future controlled studies are needed to determine the most cost-effective method of providing bowel preparation for colorectal surgery.

References

- Nichols RL, Condon RE. Preoperative preparation of the colon. *Surg Gynecol Obstet* 1971;132:323-37.
- Baum ML, Anish DS, Chalmer TC, Sacks H, Smith H, Fagerstrom RM. A survey of clinical trials of antibiotics prophylaxis in colon surgery: evidence against further use of no-treatment controls. *N Engl J Med* 1981;305:795-9.
- Munster AM, Weiner J, Gibson G. Prophylactic antibiotics in surgery. *JAMA* 1979;241:717-8.
- Hoffman CE, McDonald PJ, Watts JM. Use of preoperative cefoxitin to prevent infection after colonic and rectal surgery. *Ann Surg* 1981;193:353-6.
- Clark JS, Condon RE, Bartlett JG, Gorbach SL, Nichols RL, Ochi S. Preoperative oral antibiotics reduce septic complications of colon operations: results of prospective, randomized, double blind clinical study. *Ann Surg* 1977;186:251-8.
- Hewitt J, Rigby J, Reeve J, Cox AG. Whole-gut irrigation in preparation for large bowel surgery. *Lancet* 1973;2:337-40.
- Chung RS, Gurll NJ, Berglund EM. A controlled clinical trial of whole-gut lavage as a method of bowel preparation for colonic surgery. *Am J Surg* 1979;137:75-81.
- Panton ON, Atkinson KG, Crichton EP, Schulzer M, Beaufoy A, Germann E. Mechanical preparation of the large bowel for elective surgery: comparison of whole-gut lavage with the conventional enema and purgative technique. *Am J Surg* 1985;149:615-9.
- Gottrup F, Diederich P, Sorensen K, Nielsen SV, Ornholt J, Brandsborg O. Prophylaxis with whole-gut irrigation and antimicrobials in colorectal surgery: a prospective, randomized double-blind clinical trial.
- Keighley MR, Taylor EW, Hares MM. Influences of oral mannitol bowel preparation on colonic microflora and the risk of explosion during endoscopy diathermy. *Br J Surg* 1981;68:554-8.
- Hare MM, Alexander-Williams J. The effect of bowel preparation on colonic surgery. *World J Surg* 1982;6:175-81.
- Jagelman DG, Fazio VW, Lavery IC, Weakley FL. A prospective, randomized, double blind study of 10% mannitol mechanical bowel preparation combined with oral neomycin and short-term, preoperative, intravenous flagyl as prophylaxis in elective colorectal resections. *Surgery* 1985;98:861-5.
- Bigard MA, Gaucher P, Lassalle C. Fatal colonic explosion during colonoscopic polypectomy. *Gastroenterology* 1979;77:1307-10.
- David GR, SantaAna CA, Morawski SG, Fordtran JS. Development of a lavage solution associated with minimal water and electrolyte absorption or secretion. *Gastroenterology* 1980;78:991-5.
- Bowden TA, DiPira JT, Micael KA. Polyethylene glycol electrolyte solution: a rapid, safe mechanical bowel preparation for colorectal surgery. *Am Surg* 1987;53:34-6.
- Beck DE, Harford FJ, Di Palma JA. Comparison of cleansing methods in preparation for colonic surgery. *Dis Colon Rectum* 1985;28:491-5.
- Dueholm S, Rubinstein E, Reipurth G. Preparation for elective colorectal surgery: a randomized, blinded comparison between oral colonic lavage and whole-gut irrigation. *Dis Colon Rectum* 1987;30:360-4.
- Polk HC, Lopez-Mayor JF. Postoperative wound infection: a prospective study of determinant factors and prevention. *Surgery* 1969;66:97-103.
- Kelly MJ. Wound infection: a controlled clinical experimental demonstration of synergy between aerobic *Escherichia coli* and anaerobic *Bacteroides fragilis* bacteria. *Ann R Coll Surg Engl* 1980;62:52-9.
- De La Hunt MN, Karran SJ. Sulbactam/ampicillin compared with cefoxitin for chemoprophylaxis in elective colorectal surgery. *Dis Colon Rectum* 1986;29:157-9.
- McDonald PJ, Karran SJ. A comparison of intravenous cefoxitin and a combination of gentamicin and metronidazole as prophylaxis in colorectal surgery. *Dis Colon Rectum* 1983;26:661-4.
- Panichi G, Pantosi A, Giunchi G, et al. Cephalothin, cefoxitin, or metronidazole in elective colonic surgery? A single-blind randomized trial. *Dis Colon Rectum* 1982;25:783-6.
- Milermayer H, Gross C, Brucke P. Single dose cefuroxime/metronidazole versus metronidazole alone in elective colorectal surgery. *Am Surg* 1984;50:418-23.
- The Norwegian study group for colorectal surgery. *Surgery* 1985;94:402-8.
- Coppa GE, Eng K, Gouge TH, Ranson JH, Localio SA. Parenteral and oral antibiotics in elective colon and rectal surgery. *Am J Surg* 1983;145:62-5.
- Stone HH, Hooper CA, Kolb LD, Geheber CE, Dawkins JE. Antibiotic prophylaxis in gastric, biliary and colonic surgery. *Ann Surg* 1976;184:443-40.
- Kaiser AB, Herrington JL, Jacobs JK, Mulherin JL, Roach AC, Sawyers JL. Cefoxitin vs erythromycin, neomycin and cefazolin in colorectal surgery: importance of the duration of the operative procedure. *Ann Surg* 1983;198:525-30.
- Willis AT, Ferguson IR, Jones PH, Phillips KD, Tearle PV, Fiddian RV. Metronidazole in prevention and treatment of bacteroides infections in elective colonic surgery. *Br Med J* 1977;1:607-10.
- Hanel KC, King DW, McAllister ET, Reiss-Levy E. Single-dose parenteral antibiotics as prophylaxis against wound infections in colonic operations. *Dis Colon Rectum* 1980;23:98-101.
- Keighley MR. A clinical and physiological evaluation of bowel preparation for elective colorectal surgery. *World J Surg* 1982;6:464-70.
- Peck JJ, Fuchs PC, Gustafson ME. Antimicrobial prophylaxis in elective colon surgery: experience of 1,035 operations in a community hospital. *Am J Surg* 1984;147:633-7.
- Portnoy J, Kagan E, Gordon PH, Mendelson J. Prophylactic antibiotics in elective colorectal surgery. *Dis Colon Rectum* 1983;26:310-13.
- Pello JM, Beauregard W, Shaika K, Camishion RC. Colon

- operations without wound infection: principles and techniques of 101 cases. *Am Surg* 1984;50:362-5.
34. Lazorthes F, Legrand G, Monrozier X, et al. Comparison between oral and systemic antibiotics and their combined use for the prevention of complications in colorectal surgery. *Dis Colon Rectum* 1982;25:309-11.
35. Condon RE. Bowel preparation for colorectal operations. *Arch Surg* 1982;117:265.
36. Condon RE, Bartlett JG, Nichols RL, Schulte WJ, Gorbach SL, Ochi S. Preoperative prophylactic cephalothin fails to control septic complications of colorectal operations: results of controlled clinical trial. A Veterans Administration cooperative study. *Am J Surg* 1979;137:58-74.
37. Condon RE, Bartlett JG, Greenlee H, et al. Efficacy of oral and systemic antibiotic prophylaxis in colorectal operations. *Arch Surg* 1983;118:496-502.
38. Condon RE. Antibiotic bowel preparation for surgery. *Confronting Infection, Cases and Commentary*. Wilmington: Stuart Pharmaceuticals, 1987;5:1-12.
39. Barber MS, Hirschberg BC, Rice CL, Atkins CC. Parenteral antibiotics in elective controlled trial. *Surgery* 1979;86:23-8.
40. Brown JJ, Mutton TP, Wasilaukas BL, Myers RT, Meredith JH. Prospective, randomized, controlled trial of ticarcillin and cephalothin as prophylactic antibiotics for gastrointestinal operations. *Am J Surg* 1982;143:343-8.
41. Eisenberg HW. The use of new antibiotics in colorectal surgery. *Am J Proctol* 1981;32:9-26.