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Influence of oral mannitol bowel preparation on colonic microflora and the risk of explosion during endoscopic diathermy

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SUMMARY

Oral mannitol has been widely accepted as the bowel preparation of choice for colonoscopy and elective colorectal operation because it is well tolerated by patients. Recent concern has been expressed regarding the risk of explosion and sepsis using oral mannitol because it may provide a nutrient for certain gas-producing bacteria in the colon. Samples of colonic contents aspirated at operation were compared in patients prepared by oral mannitol, by whole bowel irrigation, mannitol preceded by 48 h of oral antibiotics (neomycin with metronidazole) and in patients who did not undergo any preparation. Significantly higher counts of gas-producing Escherichia coli were recovered from patients prepared with mannitol alone compared with whole bowel irrigation or mannitol preceded by oral antimicrobials. These data are consistent with the hypothesis that fermentation of mannitol by Escherichia coli is responsible for the production of potentially explosive gas mixtures after oral mannitol preparation and may also explain the increased incidence of sepsis when oral mannitol is used for bowel preparation.

ORAL mannitol has become a popular method of mechanical bowel preparation for colonoscopy (1), elective colorectal operation (2) and for barium enema (3). However, there has been recent concern about the potential explosive hazard of mannitol (4, 5) and, as this oligosaccharide is fermentable by certain bacteria, it may provide a nutrient for gas-producing organisms in the bowel. In addition, we have noted an increased incidence of postoperative sepsis when oral mannitol was used for bowel preparation despite the use of systemic antibiotics (6). For these reasons we felt that there was a need to study the colonic microflora of patients receiving oral mannitol.

Patients and methods

Samples of colonic contents were collected from a 10-cm segment of the transverse colon isolated with non-crushing clamps, during operation for colorectal carcinoma. Ten millilitres of normal saline were injected into the segment of colon. After thorough mixing for 1 min, a sample of diluted colonic contents was aspirated and despatched immediately to the microbiology laboratory as previously described (7). In most of the patients receiving mannitol, samples of colonic gas were also collected in a similar manner before saline injection. The colonic gas was aspirated into a 50-ml syringe fitted with a three-way tap and the gas was analysed with a mass spectrometer, the details of which are to be published elsewhere (8).

Tenfold dilutions of the colonic fluid were prepared in an anaerobic cabinet and inoculated onto a series of selective media for viable counts of organisms using the single drop technique (9). Serial dilutions were prepared within 20 min of collection. The aerobic media included MacConkey agar, MacConkey agar with colistin, blood agar, blood agar with colistin and kanamycin and mannitol salt agar. The anaerobic media consisted of lysed blood agar with menadione and kanamycin and Rogosa agar. Each isolate from patients given oral mannitol was tested for acid and gas production by incubation in mannitol peptone water containing a Durham tube.

Four groups have been studied:

1. Patients receiving oral mannitol alone ($n = 11$).
2. Patients receiving oral mannitol with oral neomycin (1 g 8 hourly) and oral metronidazole (400 mg 8 hourly) for 48 h before operation ($n = 11$).
3. Patients prepared by whole bowel irrigation alone ($n = 11$).
4. Patients having elective peptic ulcer surgery or operation on the biliary tract who had had no preoperative bowel preparation ($n = 11$).

Viable counts of the faecal microflora have been compared with the proportion of patients in each group who had explosive or potentially explosive contents of hydrogen and methane in the colonic gas. Only after oral mannitol was gas analysed and viable counts performed in the same patients.

Results

The colonic microflora in patients prepared by oral mannitol alone did not differ significantly from patients having no mechanical preparation, although there was a tenfold increase in the counts of *Escherichia coli*. Patients who were given oral neomycin and metronidazole for 48 h before operation with mannitol preparation had no evidence of Klebsiella spp., Proteus spp., Staphylococcus spp., Bacteroides spp., Peptostreptococcus spp. or Bifidobacterium spp. in the colon, and the mean count of *Escherichia coli* was only 7×10^1. The mean count of *Escherichia coli* after oral mannitol alone was 8×10^8, which was significantly higher than those observed after whole bowel irrigation (9×10^5) and higher than the counts of *Escherichia coli* in the unprepared patients (8×10^7). No other differences in faecal flora were detected after oral mannitol alone (*Table I*). The organisms which were shown to be capable of gas production with mannitol included: 10 of the 11 isolates of *Escherichia coli*, one of 2 isolates of Klebsiella spp., one of 3 isolates of Proteus spp., one of 7 isolates of Lactobacilli, 2 of 13 isolates of Bacteroides spp. and 2 of 6 isolates of Clostridium spp. It is clear, therefore, that *Escherichia coli* was the principal gas-producing bacterium in the colon. Acid production after incubation with mannitol but without formation of gas was more common and occurred with many bacterial species including *Escherichia coli* and some isolates of Klebsiella spp., Enterobacter spp., Citrobacter spp. and *Bacteroides fragilis*.

When the counts of *Escherichia coli* from individual patients were considered (*Table II*), 5 patients had counts greater than 10^9 organisms/ml after oral mannitol, compared with none after mannitol and antibiotics, 2 after whole bowel irrigation and only 1 after no preparation. There was a close association in patients prepared with mannitol between counts of the

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Table I: MEAN COUNTS OF COLONIC BACTERIA (log_{10})

	Mannitol alone ($n = 11$)	Mannitol + antibiotic ($n = 11$)	Whole bowel irrigation ($n = 11$)	No preparation ($n = 11$)
Staphylococcus albus	8×10^2	—	4×10^1	9×10^1
Staphylococcus aureus	—	—	—	—
Streptococcus viridans	7×10^1	—	5×10^2	5×10^1
Streptococcus faecalis	2×10^5	1×10^3	3×10^4	2×10^4
Escherichia coli	8×10^8*	7×10^1	9×10^5	8×10^7
Klebsiella spp.	6×10^2	—	8×10^1	9×10^1
Proteus spp.	6×10^2	—	1×10^2	9×10^2
Pseudomonas aeruginosa	8×10^1	—	5×10^1	—
Bacteroides fragilis	2×10^8	—	5×10^9	7×10^9
Bacteroides melaninogenicus	7×10^2	—	4×10^3	7×10^1
Peptostreptococcus spp.	7×10^3	—	2×10^3	4×10^1
Clostridium spp.	2×10^5	7×10^1	6×10^3	9×10^3
Bifidobacterium spp.	8×10^2	—	4×10^1	9×10^1
Veillonella spp.	9×10^2	—	2×10^2	—

* $P < 0{\cdot}001$ compared with mannitol + antibiotic and whole bowel irrigation.

Table II: COUNTS OF *Escherichia coli* (log_{10})

	Mannitol alone ($n = 11$)	Mannitol + antibiotic ($n = 11$)	Whole bowel irrigation ($n = 11$)	No preparation ($n = 11$)
None present	0	10	0	0
10^1–10^3	0	0	0	0
10^3–10^6	0	0	6	0
10^6–10^9	6	1	3	10
$>10^9$	5	0	2	1

principal gas-producing organism *Escherichia coli* and the proportion of patients with explosive or potentially explosive colonic gas. Potentially explosive colonic gas was recorded in 7 patients prepared with oral mannitol, 5 of whom had counts of *Escherichia coli* greater than 10^9 and none of the patients receiving mannitol with antibiotics had potentially explosive gas mixtures. This is in contrast to a separate group of 11 patients having whole bowel irrigation and 11 having no bowel preparation, where the number identified as containing explosive gas mixtures was 1 and 4 respectively.

Discussion

Two facts have promoted this study. The first is the alarming report that a fatal explosion has occurred after colonoscopic polypectomy following oral mannitol bowel preparation (10), and the knowledge that many patients prepared with oral mannitol have explosive or potentially explosive gas contents in the colon (11). The second has been the result of an audit on the rate of sepsis in colorectal operations in this hospital. Despite antibiotic cover with cefoxitin or the combination of metronidazole and gentamicin, the rate of sepsis using oral mannitol alone was 40 per cent in 37 patients, compared with only 12·5 per cent in 32 patients having whole bowel irrigation (6). We therefore felt that the mechanism of colonic gas production and the increased risk of sepsis required careful investigation.

We preferred to use material aspirated from the transverse colon in preference to faecal samples for two reasons. The first was that colonic gas was being sampled by the same technique in the patients anyway and, secondly, that satisfactory faecal material is often difficult to obtain even by sigmoidoscopy at operation. All of the patients received an antibiotic as soon as the material had been aspirated from the colon, and others have not found this technique to be attended by any increased morbidity (12).

The ability of organisms isolated from the colon to produce acid and gas in the presence of mannitol was only investigated in the two groups receiving mannitol and not in the remaining patients. Nevertheless, *Escherichia coli* appears to have been the principal gas-producing organism. Therefore, it is of interest that the only difference in the density of the faecal flora related to changes in the counts of *Escherichia coli* with an increase after oral mannitol by a factor of between 100 and 1000 when compared with whole bowel irrigation. Furthermore, in our series, *Escherichia coli* was the principal cause of sepsis following oral mannitol bowel preparation, being isolated from 11 of 16 patients with sepsis.

In view of the risk of explosion and the increased incidence of sepsis with oral mannitol, alternative methods of preparation of the colon must be sought, particularly if diathermy is to be used or if operation is planned. These results have shown that if oral metronidazole and neomycin are used for 48 h before giving oral mannitol the gas-producing organisms are completely eliminated from the colon, the risk of explosive gas mixtures is no longer present and previous studies show that postoperative infection is low (13). However, there are dangers in using oral neomycin with metronidazole for preparation of the colon. These include emergence of neomycin-resistant strains of *Escherichia coli*, overgrowth with *Staphylococcus aureus* (14) and, occasionally, pseudomembranous colitis. Mannitol has been widely accepted by colonoscopists and surgeons for bowel preparation because it provides good bowel clearance with minimal patient discomfort (15). Oral mannitol avoids the need for repeated enemas and the passage of a nasogastric tube, which are disadvantages of standard bowel preparations or whole bowel irrigation. Further, mannitol, unlike whole bowel irrigation, is not associated with sodium and water retention and therefore makes mannitol a much safer agent for bowel preparation in the elderly patient with cardiac disease. For these reasons a search should be made for an alternative osmotic cathartic which will not provide a nutrient for gas-producing bacteria in the colon.

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