

Bowel preparation and the risk of explosion during colonoscopic polypectomy

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SUMMARY Concentration of oxygen, methane, and hydrogen were measured in intracolonic gas samples aspirated through the colonoscope at the time of colonoscopy from 46 patients. Of the above patients 20 prepared either with mannitol (n=10) or with castor oil (n=10) had the instrument passed to the caecum without air insufflation or suction. After mannitol, mean intracolonic hydrogen concentration (4.07%) was significantly higher ($p < 0.001$) than after castor oil (0.51%). Mean oxygen and methane concentrations were approximately similar. Potentially explosive concentrations of hydrogen (>4.1%) and or methane (>5%) were present in 6/10 patients given mannitol and 2/10 patients given castor oil. Nevertheless only one patient from each group had coexisting oxygen concentrations of more than 5% producing thus a combustile mixture. Routine colonoscopy (using air insufflation and suction) was performed in 26 patients prepared with mannitol. Mean intracolonic hydrogen and methane was 0.63% and 0.88% respectively. The highest recorded concentration of hydrogen was 2.6%, and of methane 2.1%, while all patients had oxygen concentrations of more than 5%. It is suggested, therefore, that routine insufflation and suction before colonoscopic electrosurgical polypectomy should result in safe levels of these gases. The remote possibility of pockets of undiluted gas in explosive concentration, however, indicates the use of an inert gas such as carbon dioxide if mannitol preparation is used before electrosurgery.

One of the potential hazards of electrocauterising polyps, colonic explosion, has been attributed to the presence of inflammable gases, chiefly hydrogen (H_2) and methane (CH_4) in the colon.^{1,2} The formation of H_2 is dependent upon the delivery of ingested fermentable material to the colonic bacteria while CH_4 production does not have a clear cut relation to diet.^{3,4} The potentially explosive range of H_2 is 4.1-72% and of CH_4 is 5-15%. Neither H_2 nor CH_4 , however, is combustible if O_2 concentration is less than 5% in the total gas mixture.^{5,6}

Mannitol administration has been implicated recently as the substrate responsible for production of potentially explosive concentration of hydrogen.⁷ Oxygen and methane concentrations, however, were not calculated in this study.

The aim of the present study was to clarify the explosive potential of mannitol and castor oil bowel preparation, during colonoscopic polypectomy. We therefore measured the concentrations of O_2 , CH_4 and H_2 in colonic gas through the colonoscope at the time of colonoscopy.

Methods

PATIENTS

Fifty one patients were studied; 42 had been referred for colonoscopy because of rectal bleeding or diarrhoea or both and nine because of colonic polyps detected after barium enema.

Patients with proven active inflammatory, or diverticular bowel disease or colonic resection were excluded because they might have had abnormal bacterial flora or motility which could affect the results. Patients were divided into two groups: group 1 comprised of 25 patients none of whom had air insufflation. Of these 11 were randomly allocated

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to mannitol preparation and 14 to castor oil and enema procedure. Group 2 comprised of 26 patients who had air insufflation and were prepared only with mannitol. All patients had a low residue diet for 48 hours before colonoscopy. The night before colonoscopy patients were given mannitol 100 g as a 10% solution which they drunk during a period of two to three hours. Patients taking castor oil were subject to the same dietary restrictions and took 50 ml of the aperient the night before. They had tap water enemas until returns were clear. All colonoscopies were performed during the next morning. Patients were sedated with diazepam 10 mg and pethidine 50 mg intravenously immediately before colonoscopy. An Olympus CF-IBW colonoscope was used with the patients in the left lateral position.

In group 1 we attempted to pass the instrument to the caecum entirely, without air insufflation or suction. Intermittent infusions of small quantities of water were used as necessary. Not more than 400 ml of water was infused in any one occasion. All colonic gas encountered during colonoscopy was aspirated into 60 ml syringes *via* a polyvinyl tube which protruded 2–3 mm from the suction channel. In group 2, prepared with mannitol, intracolonic gas concentrations were measured in samples aspirated during routine colonoscopy using air insufflation and suction. In this group sites of aspiration were identified as left, transverse and right colon.

Oxygen, methane and hydrogen concentrations were measured in each sample aspirated during colonoscopy. The gas samples were analysed immediately by gas chromatography in a 5750 Hewlett Packard research gas chromatograph, using a molecular sieve column (5A 60/80 mesh). The column used was 2.8 metres in length and of an internal diameter of 6.3 mm. The chromatograph was set to measure gas constituents from 10⁻⁴% to 20%. The sample was introduced into the chromatograph at a rate of 24 ml/min. The column temperature was set at 50°C, the TC detector temperature at 100°C, and the bridge current at 160 mA; a 2 ml sample loop was used. Gas concentrations were calibrated with standard gases containing hydrogen 1% and 5%, methane 1% and 5% and oxygen 1%

and 5%. The Wilcoxon's rank sum test was used for statistical analysis.

Results

GROUP 1

In all patients bowel cleansing was considered very good and the caecum was reached without air insufflation or suction in 20 of them. The other five were excluded from the study. Colonoscopy was normal in 16 subjects while four had colonic polyps. The two subgroups of 10 patients were matched for sex and age (Table).

Nineteen samples of colonic gas were aspirated from the 10 patients prepared with mannitol. Most of the gas pockets were located in the transverse or in the right colon and a few in the left colon. In one patient, prepared with castor oil, no gas was found at colonoscopy and was thus excluded from further analysis. Fourteen samples were aspirated from the remaining nine patients. Volumes of the gas samples varied from 3–50 ml. The mean volume of colonic gas aspirated per sample in the mannitol group was 22.9±3.01 ml SEM compared with 12.8±1.44 ml SEM in the castor oil group. This difference was significant ($p<0.05$). Individual concentrations of O₂, H₂, and CH₄ in the group of patients studied are shown in Figs. 1, 2, and 3. Oral mannitol alone produced a mean hydrogen concentration of 4.07±0.65% SEM compared with 0.51±0.11% SEM after castor oil preparation. This difference was significant ($p<0.001$). The mean methane concentration after oral mannitol was 1.83±0.51% SEM and did not differ from the mean concentration of 1.17±0.58% SEM after castor oil preparation. The mean O₂ concentrations were also similar (2.6±0.66% SEM to 2.68±0.65% SEM respectively). Potentially explosive concentrations of H₂ were recorded in nine (six patients) out of the 19 collected samples in the mannitol group while such concentrations of methane were present only in two samples (two patients) (Figs. 2 and 3). In the castor oil prepared patients none of the samples contained potentially explosive concentrations of H₂, but in two samples (two patients) explosive concentrations

Table Clinical details of patients

| | Bowel preparation | No (M/F) | Mean age (yr) (range) | Mean ± SEM duration of colonoscopy (min) | Patients with abnormal colonoscopic findings (no) |
|---------|-------------------|------------|-----------------------|--|---|
| Group 1 | Mannitol | 10 (6/4) | 36.2 (19–49) | 42.5±3.74 | 3 colonic polyps |
| | Castor oil | 10 (4/6) | 42.9 (26–70) | 43.8±3.83 | 1 colonic polyp |
| Group 2 | Mannitol | 26 (15/11) | 43.9 (24–70) | 22.7±1.82 | 2 colonic polyps 3 colitis |

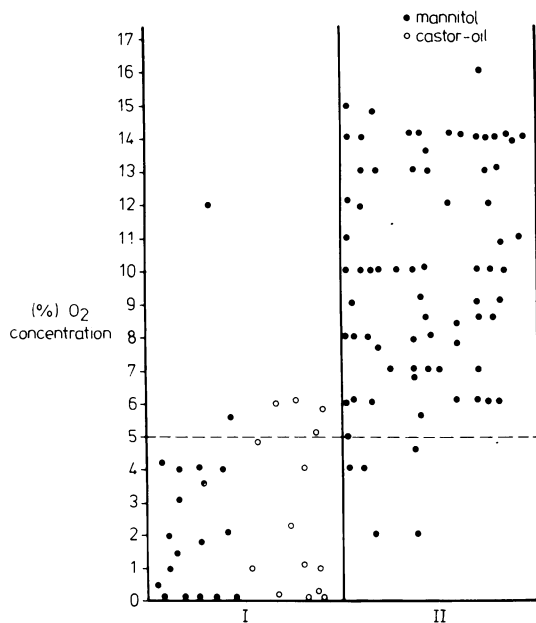


Fig. 1 Recorded oxygen levels in two groups of patients (1, 2) studied. Interrupted line represents lower limit of O_2 under which H_2 or CH_4 are not combustible.

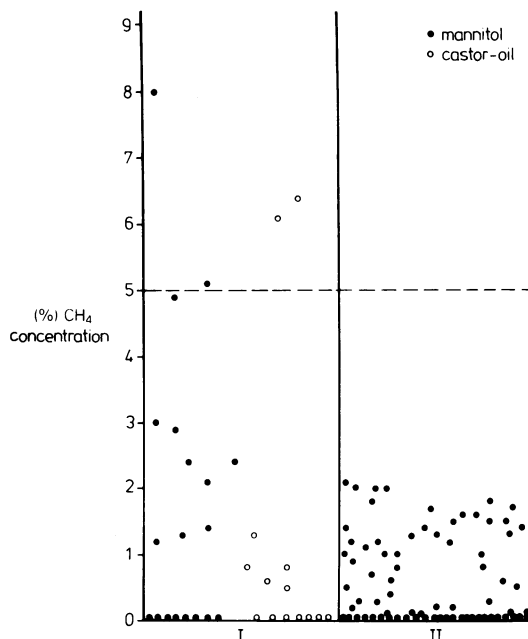


Fig. 3 Recorded methane levels. Interrupted line represents lower potentially explosive limit.

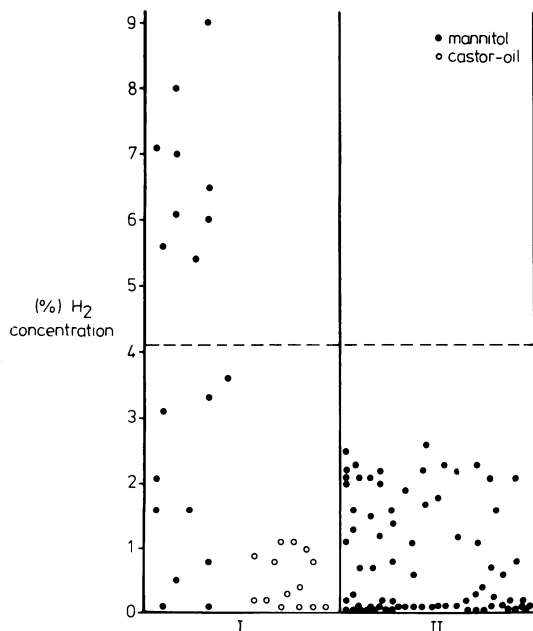


Fig. 2 Recorded hydrogen levels. Interrupted line represents the lower potentially explosive limit.

of CH_4 were present. Only in two samples (aspirated from one patient) of the mannitol group as well as in one of the castor oil group with potentially explosive concentrations of H_2 and or CH_4 , however, had O_2 concentrations greater than 5%.

GROUP 2

In all patients bowel cleansing was considered very good. The mean duration of colonoscopy was shorter than in group 1 because the procedure was facilitated by air insufflation and suction (Table). Twenty one patients had normal colonoscopy, three had inactive inflammatory bowel disease and two had colonic polyps. The mean H_2 concentration in the 74 samples aspirated using the technique described above was $0.88 \pm 0.11\%$ SEM and was significantly lower ($p < 0.001$) than in the mannitol patients of group 1. None of the samples contained potentially explosive concentrations of H_2 . The highest recorded concentration of H_2 was 2.6% (Fig. 2). The mean CH_4 concentration in the above samples was $(0.63 \pm 0.08\%$ SEM) and was significantly lower ($p < 0.05$) than in the mannitol patients of group 1 while the highest recorded concentration was 2.1% (Fig. 3). Mean O_2 concentration was

9.79±0.39% SEM and was significantly higher ($p<0.001$) than in group 1 (Fig. 1). Hence none of the patients receiving mannitol had explosive concentrations of colonic gas despite air insufflation.

Discussion

The present study confirms that larger amounts of hydrogen are present in pure colonic gas after mannitol than after conventional castor oil bowel preparation. Our results indicate, however, that the risk of explosion after mannitol preparation during colonoscopic polypectomy is much lower than previously reported.⁷ Only one of the six patients examined without air insufflation (group 1) who had potentially explosive concentrations of H₂ and or CH₄ also had O₂ concentration above 5%, thus producing a combustible mixture. Nevertheless it is of interest that high levels of CH₄ in potentially explosive levels were also present in two patients receiving castor oil, while O₂ was present in sufficient amounts for combustion in one of them.

Presumably to cause an explosion electrosurgery would have to be performed in a pocket of intraluminal colonic gas containing high concentrations of inflammable gas in explosive mixtures, protected from air insufflation and suction. This study shows that such conditions could occur after mannitol or castor oil bowel preparation. As expected, H₂ and CH₄ concentrations were significantly lower during colonoscopy with air insufflation than in undiluted colonic gas. None were in the explosive range.

Despite the widespread use of colonoscopic electrosurgical polypectomy only two explosions have been reported^{8,9} indicating that the risk is small. This is probably because air or CO₂ insufflation and suction used in routine colonoscopy dilute colonic gas to well below the explosive levels. Furthermore, the addition of an inert gas such as CO₂ to an explosive mixture decreases the chemical potential of both the combustible gas and O₂. Thus greater concentrations of these gases are required to overcome the potential barrier of the reaction. It has been reported⁵ that CO₂ insufflation raises the explosive limit of H₂ and CH₄ to more than 50% and

29% respectively, which are much higher than any of the concentrations we recorded in undiluted colonic gas (Figs. 2, 3).

This study shows that colonoscopic electrosurgery under air insufflation and suction should be safe. It should be pointed out, however, that in one reported case of explosion colonoscopy was performed under air insufflation and suction, indicating that a risk may still exist.⁹ Therefore we believe that it is prudent if electrosurgery is intended after mannitol bowel preparation to exclude O₂ by insufflating with a gas that will not support combustion. Carbon dioxide is suitable for this purpose whereas nitrous oxide⁸ is not.

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