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## The Effects of Nitrous Oxide on Postoperative Bowel Motility

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The gastrointestinal effects of nitrous oxide anesthesia were studied 60 yr ago.<sup>1</sup> Because of its physical properties, nitrous oxide causes a dramatic increase in the volume of bowel gas, even in the absence of intestinal ileus.<sup>2,3</sup> Peristalsis also may be slightly decreased in bowel exposed to nitrous oxide.<sup>4</sup> However, the effect of nitrous oxide, either directly or as a result of bowel distension, on the return of bowel motility after abdominal surgery in humans remains unknown. We designed the present study to investigate this question.

### METHODS

Twenty men, ASA I-III, scheduled to undergo elective abdominal surgery, gave written, informed consent to participate in this Institutional Review Board approved study. We excluded patients who did not understand English, had any mental impairment that would interfere with their ability to comprehend the consent procedure, had any underlying problems of bowel motility, were taking medications that could affect bowel motility, or had any condition such as bullous emphysema or closed loop bowel obstruction that would contraindicate the use of nitrous oxide.

Using a computer-generated randomization table, we assigned patients to either the experimental or control group. After induction of anesthesia with thiopental and paralysis with succinylcholine, we intubated each patient's trachea. For maintenance of anesthesia, control-group patients received isoflurane in oxygen, while experimental-group patients received 60% nitrous oxide in oxygen with isoflurane. At the discretion of the attending anesthesiologist (who, because of practical and safety considerations could not be made "blind" to the group assign-

ments), *d*-tubocurarine, pancuronium, or atracurium was administered to provide relaxation. A mass spectrometer system (AIMT SARA®) continually monitored and recorded inspired and end-tidal concentrations of respiratory and anesthetic gases. At the end of surgery, we reversed neuromuscular blockade with neostigmine 3 mg and atropine 1 mg and verified a negative inspiratory pressure of greater than 20 cmH<sub>2</sub>O before tracheal extubation. We then returned patients to the postanesthesia room until they were fully awake.

An investigator, "blind" to group assignment, visited the patients at least twice on each postoperative day to determine the time until return of flatulence, ingestion of liquids, ingestion of solids, and first bowel movement (variables thought to indicate return of bowel activity). After completion of the study, we used the anesthesia and spectrometer records to determine subject's age; type of surgery; and type, duration, and concentration of anesthetic gas administration. Student's *t* test was used to determine the statistical significance of differences between the groups;  $P \leq 0.05$  indicated statistical significance.

### RESULTS

The two groups were similar with regard to age, duration, and concentration of anesthesia (table 1), and type of surgery (table 2).

Because the mass spectrometer displays in our operating rooms can easily be seen by the surgeons, it was impossible to "blind" them with regard to the use of nitrous oxide. However, in most of the instances when nitrous oxide was used, the surgeons spontaneously commented on the presence of a greater degree of bowel distention than usual. Despite this distension, there was no apparent or statistically significant difference between the groups in any of the dependent variables indicative of the return of bowel function (table 3). There was also no relationship between receipt of nitrous oxide and postoperative nausea or vomiting; however, the incidence of nausea and vomiting was so low, a relationship, if it existed, would not be obvious in a sample this small.

### DISCUSSION

Nitrous oxide is commonly used as an adjunct to the potent inhaled anesthetics. Advantages of nitrous oxide include its minimal hemodynamic effects and its rapid up-

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TABLE 1. Distribution of Descriptive Variables

	Isoflurane (n = 11)	Isoflurane and Nitrous Oxide (n = 9)
Age (yr)	62.1 ± 7.2	58.7 ± 9.6
Duration of anesthesia (min)	204.5 ± 20.0	212.8 ± 13.0
End-tidal concentration of isoflurane (%)	0.8 ± 0.2	1.0 ± 0.1

Values are means ± SE.

take and elimination. The latter effects are related to its relatively low (compared with other nonexplosive anesthetics) solubility in blood and tissues. However, nitrous oxide is approximately 30 times more soluble in blood than is nitrogen; therefore, it is transported into gas-filled spaces such as the intestinal tract much more quickly than nitrogen can be removed. The result is a rapid expansion of these spaces to several times their initial volume, the exact increase depending on the nitrous oxide concentration and duration of exposure.<sup>2</sup> Because of this effect, nitrous oxide is contraindicated in patients with a volvulus or other closed loop bowel obstruction, the expanding intestinal loop being at risk for strangulation or rupture. Although patients without such obstruction are unlikely to develop these severe complications, our surgeons' observations during the study as well as our previous experience indicate that noticeable intestinal distention does occur during nitrous oxide administration. Furthermore, discontinuation of nitrous oxide after distention has occurred does not result in immediate reversal of the distention: the surface-to-volume ratio of distended bowel is decreased, reducing the rate of absorption of the entrained gas.

TABLE 2. Distribution of Types of Surgery

Surgery	Isoflurane	Isoflurane and Nitrous Oxide
Aorto-bi-iliac replacement graft	3	1
Cholecystectomy	1	2
Pelvic lymphadenectomy with radical retropubic prostatectomy	4	4
Splenectomy	0	1
Subtotal gastrectomy	1	0
Hemicolectomy	0	1
Colostomy	1	0
Exploratory Laparotomy	1	0

TABLE 3. Time to Return of Bowel Function

	Isoflurane	Isoflurane and Nitrous Oxide
Return of flatulence	2.5 ± 0.4	2.4 ± 0.4
First liquids	3.4 ± 0.4	2.8 ± 0.6
First solids	5.1 ± 0.3	4.2 ± 0.6
First bowel movement	4.3 ± 0.4	3.9 ± 0.4

Values are in mean days ± SE with the day of surgery considered day zero.

Despite the bowel distension associated with nitrous oxide, we observed no significant delay in return of gastrointestinal function in our patients who received it. Thus, although bowel distention and nitrous oxide, *per se*, may affect gastrointestinal motility,<sup>4</sup> these effects are relatively subtle compared with the effect of the surgery itself. The nitrous oxide may, in fact, be completely reabsorbed long before peristalsis is reestablished. Therefore, use of nitrous oxide should not be expected to prolong hospitalization of patients undergoing abdominal surgery.

Because nitrous oxide has other disadvantages—decrease in the available fraction of inspired oxygen; expansion of other air-filled cavities possibly leading to tympanic membrane perforation, tracheal compromise, or pneumothorax; and hematopoietic depression with prolonged administration—the decision to administer nitrous oxide should be made with the same care as the decision to administer any other drug.<sup>5</sup> In summary, we found that the use of nitrous oxide does not appreciably delay the return of gastrointestinal function in patients undergoing abdominal surgery.

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