Nitrous oxide pneumoperitoneum revisited

Is there a risk of combustion?

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Received: 31 October 1994/Accepted: 7 November 1994

Abstract. Nitrous oxide has been effectively banned from use in therapeutic laparoscopy because of fear of combustion. These fears rest on two case reports, a misunderstanding of the physical chemistry of nitrous oxide, and lack of information on the presence of flammable colonic gases in the pneumoperitoneum mixture. This study aims to identify the presence and quantify the amount of hydrogen and methane found in the peritoneal cavity during laparoscopic GI procedures, and then to compare the gas concentrations detected with known limits of combustion. Gas standards with known concentrations of hydrogen and methane were placed in polypropylene syringes and analyzed on a mass spectrometer after 1, 2, 3, and 4 h. This established the rate at which these gases would be leached through a polypropylene syringe—the amount of gas lost during transport from the patient to the laboratory. Twenty gas samples were drawn, randomly, 30 min to 2 h following the start of laparoscopic gastrointestinal procedures. The samples were analyzed for hydrogen and methane within 30 min of their aspiration from the abdominal cavity. An inconsequential amount of methane was lost from the polypropylene syringe in 4 h. After 1 h, one-half the hydrogen had leached from the polypropylene syringe. Hydrogen was detected in the pneumoperitoneum of four patients at a concentration ranging from 0.016 to 0.075%. No methane was detected in any sample. For combustion to occur in a nitrous oxide environment, hydrogen or methane must occupy 5.5% of the gas volume. The maximum amount of hydrogen we detected was less than 1/50 of the combustion threshold. After considering these data, and a large clinical experience of gynecologic laparoscopy using electrosurgery in a nitrous oxide pneumoperitoneum, we conclude that nitrous oxide can be safely used for creating a pneumoperitoneum during laparoscopic surgery.

Key words: Nitrous oxide — Pneumoperitoneum — Combustion

Carbon dioxide is the preferred gas for the creation of pneumoperitoneum because it is inexpensive, readily absorbed, rapidly eliminated, and suppresses combustion. However, hypercarbia, respiratory acidosis, tachycardia, and cardiac arrhythmias have been observed frequently [9, 21, 25]. These effects are of particular concern in patients with pulmonary and coronary artery disease.

Nitrous oxide was the gas preferred for pneumoperitoneum by gynecologists and gastroenterologists in the seventies and eighties [17, 20–22]. It is inexpensive, rapidly absorbed, and rapidly eliminated; it has anesthetic effects and none of the hemodynamic side effects of CO2; but it does not suppress combustion. The theoretical risk of combustion from colon gases and two sketchy case reports caused N2O to be effectively banned from use in therapeutic laparoscopy [12, 20].

Our aim was to determine the presence of two flammable colon gases, methane (CH4) and hydrogen (H2), in the pneumoperitoneum during therapeutic gastrointestinal laparoscopy and revisit the concerns about combustion of these gases during therapeutic laparoscopy in a N2O pneumoperitoneum.

Materials and methods

Control data

Twenty samples of a gas standard with CO2 99.8%, H2 0.1%, and CH4 0.1% (Scotty Mini Mix Specialty Gases, San Bernardino, CA)
were collected in sterile 20-ml polypropylene syringes and immediately sealed with a sterile polypropylene cap (Luer Lock, Becton-Dickson, Rutherford, NJ). Immediately before injection into the mass spectrometer, the cap was removed from the syringe and a 25-gauge needle was attached. The first 10 ml of gas was flushed out of the syringe. The remaining 10 ml was injected through a membrane into an evacuated gas reservoir, connected with a conventional leak to a mass spectrometer ion source (MAT 731, Warien MAT, Bremen Germany). Loss of H₂ and CH₄ from the polypropylene syringes as a function of time was determined by injecting four syringes of the gas standard into the MAT 731 immediately and at 1, 2, 3, and 4 h after collection. These control data were derived in order to determine the expected rate of CH₄ and H₂ losses from polypropylene syringes during transport of experimental samples from the operating room to the MAT 731.

**Experimental data**

During 20 clinical laparoscopic procedures (cholecystectomy—14, antireflux procedures—6), samples of the pneumoperitoneum mixture were withdrawn in duplicates at random times from 30 min to 2 h after the start of the procedure. The samples were analyzed on the MAT 731 within 30 min of collection.

**Results**

**Control data**

Loss of CH₄ through the syringe was minimal in the 4 h after collection. Greater than 50% of the initial gas concentration remained at 4 h. On the other hand, H₂ was lost from the syringes with a T₁/₂ of approximately 1 h. (Fig. 1).

**Experimental data**

In the 40 pneumoperitoneum specimens collected (20 laparoscopic procedures) no methane was detected in any sample. Hydrogen was detected in the pneumoperitoneum of four patients. The hydrogen concentration was 0.075% in two patients and in two patients it was 0.025% and 0.016% (Table 1).

**Discussion**

Development of a therapeutic pneumoperitoneum is vital for performance of laparoscopy. In the past, air, oxygen, and nitrous oxide have been used, but they have largely been replaced by carbon dioxide because carbon dioxide suppresses combustion. The true risk of combustion with standard gases has never been fully addressed, and is worth revisiting as the complications of CO₂ pneumoperitoneum become more frequently reported. The complications of CO₂ pneumoperitoneum include hypercarbia, acidosis, tachycardia, decreased stroke volume, arrhythmias, and peritoneal irritation [9, 10, 17, 18, 21-23, 25, 26]. With more prolonged laparoscopic procedures now performed on the elderly and infirm, these side effects can pose significant risks to the patient.

The establishment of CO₂ as the ideal agent for insufflation grew from concerns that sufficient amounts of CH₄ or H₂ would escape from the gut into the pneumoperitoneum, risking combustion if a suppressive environment were not used. The composition of intestinal gas depends mostly upon the site in the gastrointestinal tract from which it is obtained. Gastric gas usually has a composition similar to air. The combustible gases, hydrogen and methane, are produced in the large bowel. Methane has never been found in the small intestine, but hydrogen can be produced in the small bowel when there is bacterial overgrowth following bacterial colonization of an ileostomy. While only one-third of adults produce methane in their colon, every individual produces hydrogen within 48 h of birth [13]. Hydrogen production decreases significantly after an overnight fast, and is undetectable 24 h after initiating the fast. Fasting does not change the production of methane, but bowel cleansing with non-fermentable substrates (e.g., polyethylene glycol) reduces both to negligible levels [3, 13, 24].