

CASE REPORTS

to despropionyl norfentanyl, but this process may be impaired in patients with significant hepatic dysfunction.⁶ A literature review located a single brief case report of fentanyl-induced delirium caused by intravenous fentanyl.⁷ Although it is tempting to associate our patient's symptoms with a derangement in the metabolism or elimination of fentanyl or its metabolites, there is not sufficient information available to reach any valid conclusions, and to do so would be conjecture.

Clinicians who prescribe transdermal fentanyl should be aware of this potential complication. If central nervous system excitatory symptoms develop in a patient being treated with transdermal fentanyl, after other causes of delirium have been ruled out, consideration should be given to removing the patch and observing the patient while maintaining appropriate monitoring. An equianalgesic regimen of another opioid should be started to provide analgesia and prevent withdrawal.

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Intraabdominal Fire during Laparoscopic Cholecystectomy

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LAPAROSCOPIC surgery for elective cholecystectomy has undergone rapid acceptance since it initially was described in 1988.¹⁻³ Complications unique to laparoscopic surgery result mainly from the cardiopulmonary impact of creating a pneumoperitoneum and choice of insufflating gas.⁴⁻⁶ Overall morbidity rates of 2-5% for laparoscopic cholecystectomy compare favorably to the 4-8% documented with open procedures.⁷⁻⁹ We report a case of intraabdominal fire secondary to insufflating the incorrect concentration of carbon dioxide gas during a laparoscopic cholecystectomy.

This article is accompanied by a letter to the editor. Please see: Johnson CT: Reply from Compressed Gas Association, Inc. *ANESTHESIOLOGY* 83:879, 1995.

CASE REPORTS

Case Report

This case involves a 62-yr-old, 114-kg, 150-cm man who presented with resolving acute pancreatitis and gallstones for elective laparoscopic cholecystectomy. Physical examination was significant for obesity and dullness to percussion at both lung bases. After induction of anesthesia and tracheal intubation, anesthesia and neuromuscular blockade were maintained with 0.5–1% isoflurane in 40% O₂ in nitrogen and vecuronium as needed to maintain two twitches in response to train-of-four stimulation.

Pneumoperitoneum was achieved with a Storz Electronic Laparoflator (Karl Storz Endoscopy-America, Culver City, CA), which was connected to the carbon dioxide tank by a collar specifically pin-indexed for carbon dioxide. The necessary laparoscopic equipment was maintained on a metal cart (Medi-Mech, The Dalles, OR). The carbon dioxide cylinder was located behind the laparoscopic cart, in a metal jacketed well that concealed the lower 90% of the tank. Approximately 2 h into what had been an uneventful surgery, a 2-cm "flame" arising from the tip of the electrocautery unit was visualized on the video monitor. Seconds later, as the electrocautery was being rapidly withdrawn through the trocar, the entire video screen turned orange-red and the abdominal wall was transilluminated. The presumed fire lasted approximately 2 s. Direct visual inspection of the electrocautery tip and trocar (fig. 1) revealed that both of these instruments had undergone combustion. The abdomen was immediately

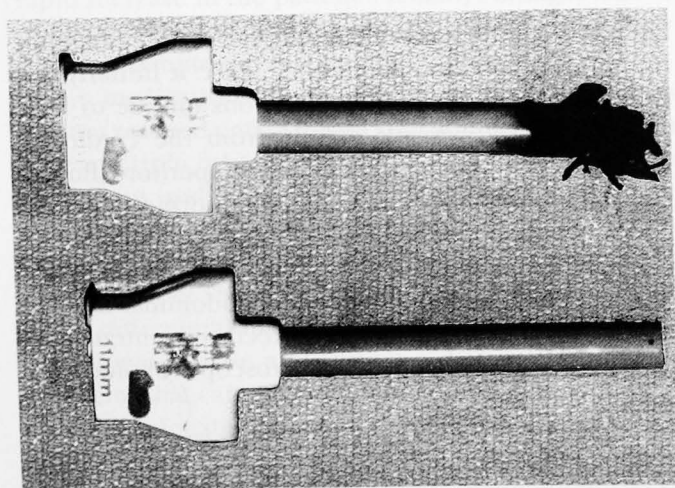


Fig. 1. Charred upper trocar, which was removed immediately from the peritoneal cavity after transillumination of the abdomen. An uncharred lower trocar is displayed for comparison.

Anesthesiology, V 83, No 4, Oct 1995

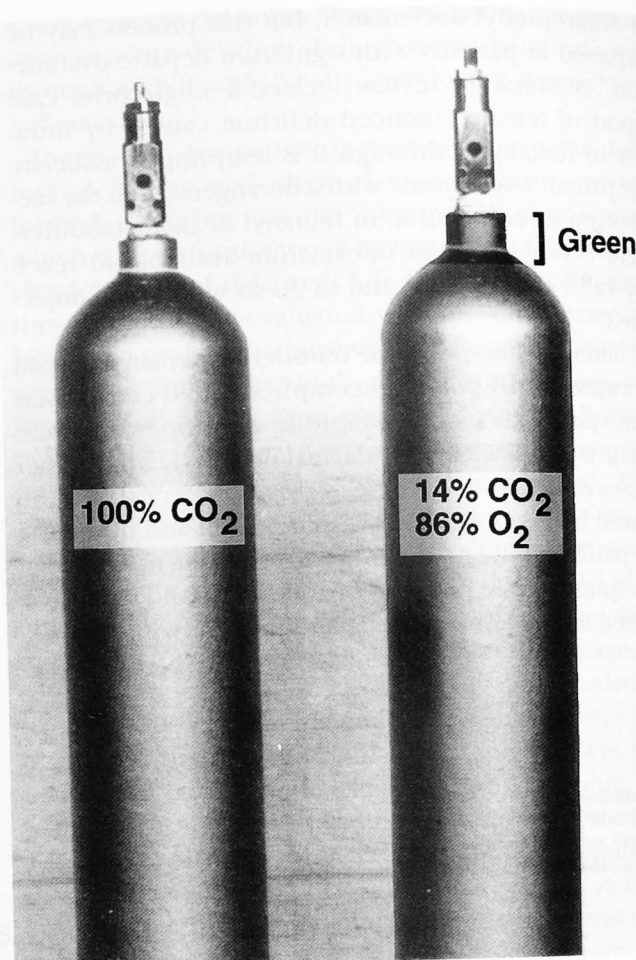


Fig. 2. Comparison of 100% CO₂ tank (left) and 14% CO₂ tank (right). Note green band at the top of the cylinder on the right, denoting the presence of oxygen. Pin-index systems for both tanks are identical.

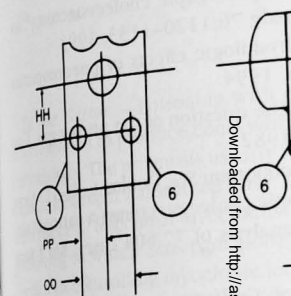
opened through a right subcostal incision. Visual inspection of the abdomen revealed no evidence of thermal injury with the exception of minor charring of the falciform ligament. Gross examination of liver, stomach, pancreas, and intestines was unremarkable. The gallbladder was removed, the peritoneal cavity lavaged with 3 liters of normal saline irrigation, and the abdomen closed in standard two-layer fashion. The remaining intraoperative and postanesthesia course proceeded without incident. The patient was discharged from the hospital on the 9th postoperative day without further complication.

After the incident, the carbon dioxide cylinder was removed from its protective metal jacket mounted on the back of the insufflator cart. Close inspection revealed a 3 cm-wide green stripe at the top of the tank, indicating the presence of oxygen (fig. 2). The re-

CASE REPORTS

PIN-INDEX
STANDARD MEDICAL
PRESSURES

Carbon Dioxide



NORMAL MIXTURE CONCENTRATION, NORMAL MIXTURE TO

mainder of the cylinder was contained carbon dioxide. The sealed label on the carbon dioxide tank indicated the gas was a mixture of 14% CO₂ and 86% O₂. A phone call to the gas supplier confirmed that no other cylinder with a carbon dioxide label other than 7% is fitted with standard pin-index system (fig. 3). Comparison of the label indicated 14% CO₂, with an oxygen concentration of 86% (fig. 2) confirmed that the gas was a mixture of 14% CO₂ and 86% O₂. None of the involved operators was aware of the potential for this type of error.

Discussion

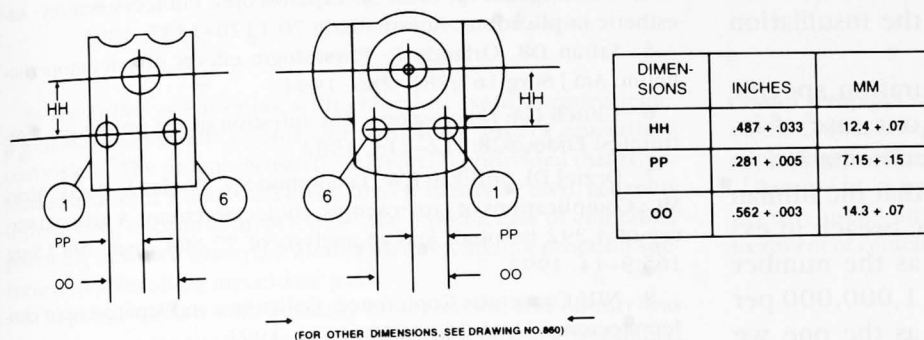
Several reports in the literature describe complications during laparoscopic surgery as the result of either pneumoperitoneum or the use of an oxidizing gas.^{10–14} The first documented abdominal explosion was a nonfatal event in 1933 when Ferver used carbon dioxide gas.¹⁰ The use of carbon dioxide for laparoscopic surgery, with both fatal and nonfatal complications in several intraabdominal explosions in the 1970s.^{11–13} Current practice is to use 100% CO₂, because it is not an oxidizing gas and does not create an explosion should

§ Manual of the Compressed Gas Cylinder Valve Outlets, 10th ed., D.C., 1994.

Anesthesiology, V 83, No 4, Oct

CASE REPORTS

PIN-INDEXED YOKE, PINS 1-6
STANDARD MEDICAL CYLINDER VALVE YOKE CONNECTION FOR
PRESSURES UP TO 3,000 psig (20 680 kPa) FOR
Carbon Dioxide
Carbon Dioxide & Oxygen Mixtures (CO₂ over 7%[§])



[§] NOMINAL MIXTURE CONCENTRATION, NORMAL MIXTURE TOLERANCES ARE ALLOWABLE

Fig. 3. Diagram of the Compressed Gas Association (CGA) specifications for tanks containing >7% CO₂ (CGA 940). The diagram on the right specifies the dimensions of the inlet valve located on the carbon dioxide collar. The diagram on the left specifies the dimensions of the outlet valve located on the carbon dioxide cylinder yolk.

mainder of the cylinder was gray, indicating the tank contained carbon dioxide. Examination of the concealed label on the carbon dioxide tank revealed that the gas was a mixture of 14% CO₂ and 86% O₂. A telephone call to the gas supply company revealed that any cylinder with a carbon dioxide content of greater than 7% is fitted with a standard pin-index for carbon dioxide (fig. 3). Comparison of our tank, which contained 14% CO₂, with another containing 100% CO₂ (fig. 2) confirmed that the pin-indexes were identical. None of the involved operating room staff were aware of the potential for this type of error.

Discussion

Several reports in the literature document major complications during laparoscopic surgery that were the result of either pneumoperitoneum or the insufflating gas.¹⁰⁻¹⁴ The first documented case of intraabdominal explosion was a nonfatal event that occurred in 1933 when Ferver used 100% O₂ as the insufflating gas.¹⁰ The use of carbon dioxide has been associated with both fatal and nonfatal injuries sustained during laparoscopic surgery.^{11,14} Nitrous oxide has been implicated in several intraabdominal explosions described in the 1970s.¹¹⁻¹³ Current surgical practice is to use 100% CO₂, because it is noncombustible and thus will not create an explosion should the electrocautery gen-

erate a spark or ignite bowel gas (methane/hydrogen).¹⁵ Diagnostic endoscopists prefer nitrous oxide, because it is better tolerated (less peritoneal irritation) in their awake patients and because they do not use electrocautery.

Several industry standards have been written and adopted to prevent the use of gases other than 100% CO₂ for laparoscopic surgery.[§] In addition, standard operating procedure at our institution only permits the placement of 100% CO₂ cylinders in our operating theater. Gas cylinders with a mixture of carbon dioxide and oxygen come from the distributor with a small green stripe at the top (fig. 2), indicating the presence of oxygen. The distributor also provides a large centrally placed label on the tank identifying the specific gas mixture within. As a further precaution, the gas insufflator collar uses the Compressed Gas Association (CGA) pin-index system, which is specific for carbon dioxide (CGA 940) concentrations greater than 7% (fig. 3). Operating room support personnel (nurses and technicians) are responsible for transporting the carbon dioxide cylinders from the storage area, mounting them on the laparoscopic carts and connecting them to the insufflating device.

Insufflation of this patient's peritoneal cavity with a gas mixture containing less than 100% CO₂ illustrates that the current safety features are not foolproof. Human error permitted a tank with a carbon dioxide/oxygen mixture into our operating theater. A member of the operating room support personnel mistakenly placed the incorrect cylinder into a metal jacket, concealing the tank's centrally placed label. This left only the thin green stripe at the top of the tank to warn

[§] Manual of the Compressed Gas Association: Standards for Compressed Gas Cylinder Valve Outlet and Inlet Connections. Washington, D.C., 1994.

CASE REPORTS

members of the operating room staff of the presence of oxygen. Finally, use of the current medical gas pin-index system, which does not distinguish tanks containing 100% CO₂ from those containing carbon dioxide mixtures between 7% and 99% permitted us to connect a tank that contained 86% O₂ to the insufflation device.

The presence of a pin-index configuration specific for 100% CO₂ would have prevented our case of intraabdominal fire. The absence of documentation in the literature of similar disasters infers that the human error made in our case represents a rare breach in existing preventive measures. However, as the number of laparoscopic procedures approaches 1,000,000 per year, the likelihood of an event such as the one we report here will increase. Until a 100% CO₂-specific pin-index fitting or appropriate safety mechanism is designed, avoidance of an intraabdominal fire relies solely on the vigilance of informed personnel. Review of this case by our quality improvement program resulted in inservice training of all operating room personnel (physicians, nurses, technicians) to alert them of this potential hazard. In addition, a more stringent check-in procedure for gas cylinders used in the operating theater was established. We report this case of intraabdominal fire during laparoscopic cholecystectomy to alert the anesthesia community of its potential to occur and to prompt efforts to eliminate this rare but potentially devastating complication.

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CORRESPONDENCE

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Propofol in t

To the Editor:—Poisoning with propofol is well known to produce coma and convulsions. The prognosis is usually poor, and treatment is instituted early with success, to control myoclonic contractions in which diazepam also succeeded in controlling myoclonic contractions.¹ A 70-yr-old woman with a history of seizures was admitted to our intensive care unit after a seizure. Four hours after ingestion of propofol, she was discovered at home, unconscious, with myoclonic contractions. After 20 mg intravenous diazepam, she was intubated and the lungs were mechanically ventilated. Despite a diazepam infusion, the myoclonic contractions persisted. At the hospital, gastric lavage was performed, and diazepam (40-mg bolus) and continuous infusion of diazepam (admission to the intensive care unit) were administered. Diazepam over 3 h of 140 mg (total 180 mg) occurred and were increased by 10 mg. Diazepam was stopped, and propofol was administered. The patient received a loading dose of propofol within 1 min, no new myoclonic contractions occurred. After 10 min, however, myoclonic contractions were observed again. A second dose of propofol was administered by an infusion of 1 mg · kg⁻¹ · h⁻¹. Further myoclonic jerks occurred, and the patient was extubated 6 h after admission, and returned to the intensive care unit after 25 h. Propofol has been noted to have myoclonic contractions in its use in the management of refractory seizures.² In this case, propofol caused myoclonic contractions by chloralose poisoning after a large dose of propofol.

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To the Editor:—Hynson et al.¹ reported on the anism of the aortoradial pressure at the conclusion of cardiopulmonary bypass. Femoral and radial arterial pressure and blood flows in six healthy 20-40 yr-old subjects at cold temperature (21°C) until shivering was induced.

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