**CASE REPORT**

Free gas in the peritoneal cavity: the final hazard of diathermy

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 Fires and explosions in the operating theatre are rare events, but are devastating in terms of structural damage to the equipment in theatres and to human lives. Fuel, oxygen, and source of ignition are the three factors causing explosion. Explosion during emergency laparotomy for perforated bowel has not been reported in the literature. In the case reported here, fuel in the form of free gas came from the perforated stomach, after cardiopulmonary resuscitation. Oxygen used during cardiopulmonary resuscitation had entered the peritoneal cavity through the perforation. The source of ignition was diathermy. It was fatal.

Fires and explosions in the operating theatre have been known for a long time, though actual explosion is a rare event. Their frequency has decreased steadily over the past 40 years partly because of changing medical practice and partly because of greater awareness of contributory factors.

Three ingredients are necessary for fire to occur: fuel, source of oxygen, and source of ignition. Gastrointestinal gases, gases produced in the bladder, skin sterilising agents, breathing systems, nebulisers, drapes, swabs, and tracheal tubes are all potential fuels. The source of oxygen is often atmospheric air but sometimes oxygen enriched gas mixture exists in the vicinity of fuel. Nitrous oxide can also generate oxygen for combustion. The source of ignition may be diathermy, cautery, faulty electrical equipment, an electrostatic charge, laser, or from adiabatic compression of oxygen.

Flammable gastrointestinal gases have been the cause of explosion in operating theatres during gastric surgery, laparoscopic procedures, colonoscopy, and polypectomy, and during the opening of a colostomy or colon with diathermy. Gases formed during cystoscopy are known to have caused bladder rupture. Alcohol based cleansing agents have resulted in severe burns to skin. Flammable inhalational anaesthetic agents and equipment for storage such as oxygen cylinders and equipment for delivery of oxygen such as nasal cannulae, tracheal tubes, and nebulisers have all caused fires. Adhesive skin drapes and laser treatment in ear, nose, and throat and oral surgery have also caused fires.

**DISCUSSION**

Flammable gases are produced at all levels of the gastrointestinal tract. Hydrogen and methane are the most common flammable gases in the bowel, their proportions varying with the diet, digestion, metabolism, and bowel preparation used. The explosive range of hydrogen is 4%–72% and of methane 5%–15% but neither is combustible in less than 5% oxygen. Oxygen concentration in the normal gastrointestinal tract decreases from 10% in the stomach to 5% in the colon, but anaesthesia using oxygen and nitrous oxide increases the concentration of both gases in the bowel.¹

Her blood results were normal except that the arterial blood gas examination on 100% oxygen showed severe metabolic acidosis.

In the casualty department the patient had a cardiac arrest after ventricular fibrillation. She had cardiopulmonary resuscitation including DC shock. After half an hour of successful resuscitation, the patient reverted back to sinus rhythm. It was then decided to perform a laparotomy for the repair of a suspected bowel perforation. After transfer to the operating theatre, the patient was anaesthetised and ventilated with 100% oxygen and the laparotomy was started.

The skin was incised in the midline with a knife and the deeper layers with cutting diathermy, level 4. As the abdominal layers were incised there was a flash explosion. The surgeon was blinded for a moment and felt heat on his face with singeing of his eyebrows and eye lashes but there was no damage to his eyesight.

After the explosion, the patient had severe hypotension, bradycardia, and irregular rhythm. Her blood pressure was brought back to normal with a bolus of adrenaline. The abdomen became flat after the explosion with the release of free gas from the peritoneal cavity.

Further laparotomy was carried out, when it was noticed that the left dome of the diaphragm had a long linear tear in its dome and the attachment of diaphragm to the ribs had been severed. The spleen had multiple superficial capsular lacerations, and the abdominal wall had all the muscles thinned out and torn apart. The above injuries were caused by the explosion. The primary pathology was found to be a large hiatus hernia with almost half of the stomach in the chest with adhesions. A large perforation in the stomach was noticed extending from the fundus into the body, and also along the greater curvature, which was presumably from strangulation. Stomach contents were found in the peritoneal cavity and also in the chest, which was suggestive of mediastinitis.

The surgical procedure included adhesiolysis of the stomach with reduction and repair of the hiatus hernia. The gastric perforation was closed with a stapler. A splenectomy was performed and the ruptured diaphragm was repaired. Chest and abdominal drains were inserted before closure of the abdomen.

Postoperatively, the patient continued to remain severely acidotic and hypotensive without any urine output and eventually died three hours after the operation.

A 77 year old woman presented to the casualty department with sudden onset of pain in the upper abdomen with nausea. On examination she had a distended abdomen associated with guarding. The bowel sounds were absent, and no mass was palpable in the abdomen. Her peripheral perfusion was inadequate with mottling of her peripheries and the prognosis appeared poor.

Chest and abdominal radiographs showed free gas under the diaphragm, and loops of bowel in the chest. These were suggestive of incarcerated hiatus hernia and perforated bowel.
Colonic hydrogen production is dependent on the metabolism of carbohydrate in the diet and its bacterial fermentation. Methane production is unrelated to diet and depends on the composition of intestinal bacterial flora. The large bowel may contain up to 40% of flammable gases. The concentration of flammable gases in the bowel can be reduced by low residue diet, fasting for 12–24 hours, and adequate bowel washout.1

The use of mannitol in the past for cleansing the bowel was shown to markedly increase the hydrogen concentration in the bowel as it is poorly absorbed and is metabolised primarily by colonic bacteria. When mannitol was used it was recommended that oral antibiotics be administered with it or that the bowel should be insufflated with carbon dioxide during colonoscopic electrosurgery. This reduced the concentration of flammable gases. Colonoscopy with polypectomy or fulguration of polyps have been known to cause explosions.2

Pyloric stenosis allows for more prolonged degradation of stomach contents by gastric acid and proliferating bacteria to occur, resulting in increased amounts of flammable gases present.1 It is advisable not to use diathermy on obstructed gastrointestinal tract. An incident has been reported where dilated stomach was opened with diathermy and a loud explosion occurred.3

In the past when oxygen or nitrous oxide were used for peritoneal insufflation during laparoscopies there were incidents of fire and explosions. Carbon dioxide used today for insufflation has the advantages of high blood solubility and thus causes less danger of gas embolus and has an inhibitory effect on flammability.4

During laparoscopy, there is a possibility of instruments perforating the bowel resulting in release of flammable gases into the peritoneal cavity and these being vulnerable to ignition by faulty electrical instrumentation. There have been reports of explosions during laparoscopic sterilisation and laparoscopic cholecystectomy.3,4 It has been shown that if nitrous oxide is being administered continuously to a patient, an increase in peritoneal concentration of nitrous oxide occurs, giving rise to the possibility of an explosion.5

A fatal case has resulted from opening a caecostomy with diathermy.1 There are rare reports of explosions occurring during a feeding jejunostomy; during a right hemicolecotomy; during a colostomy for removal of colonic polyps; and during a colon interposition for oesophageal stricture; in all four cases diathermy was used to open the bowel.

Fuel, oxygen, and source of ignition are the three important factors for explosion to occur. In our case the fuel was present from the perforated stomach in the form of free gas containing hydrogen and methane in the peritoneal cavity. The prolonged degradation of stomach contents because of incarcerated hiatus hernia, further contributed to increase in the concentration of flammable gases. Oxygen used during resuscitation entered the peritoneal cavity through the perforation. This could have occurred during the initial ventilation with mask in the casualty department, before intubation. The high concentration of oxygen with methane and hydrogen formed an explosive mixture of flammable gases; the source of ignition was the diathermy used for opening the abdomen.

**Conclusion**

One should avoid the use of diathermy to open the peritoneum in emergency laparotomy, particularly where there is free gas in the peritoneal cavity or bowel perforation is suspected. One may use diathermy, at the minimum possible current necessary, to cut the other layers of abdominal wall, but the peritoneum should be opened with a knife or scissors. Once a small opening is made in the peritoneum sufficient to let out the explosive flammable gases, the rest of the incision can be extended with the diathermy.

**REFERENCES**

5 Barkman MF. Intestinal explosion after opening a caecostomy with diathermy. BMJ 1965; i:1594–5.