Gastric Explosion Induced by Argon Plasma Coagulation and Prevention Strategies

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We describe the occurrence of an iatrogenic explosion induced by argon plasma coagulation in a 70-year-old man undergoing gastroscopy. Combustible gases in the stomach may have been released by bacterial overgrowth as a result of partial gastric outlet obstruction (caused by a gastric tumor) and reduced acidity (from proton pump inhibitor therapy). We propose a stepwise process during upper endoscopy to prevent this devastating complication, comprising aspiration, preinsufflation with CO_2, and then coagulation.

Keywords: Case Report; Combustible Gas; Explosion; Gastroscopy.

A 70-year-old man presented to our hospital with melena for 2 weeks. Adenocarcinoma of the gastric antrum was recently diagnosed and staged by abdominal computed tomography as T3N1M0. Elective chemotherapy was planned to downstage the tumor. He was on pantoprazole 40 mg twice a day. He was a nonsmoker and drank 50 g alcohol daily. On admission, he was pale but hemodynamically stable. Cardiovascular, respiratory, and abdominal examination was normal. Full blood count showed microcytic anemia, with hemoglobin of 91 g/dL.

In view of the continuing gastrointestinal bleeding, a gastroscopy was scheduled. The patient fasted for 12 hours and then underwent an uneventful rapid sequence intubation to counter the risk of aspiration. Suxamethonium, alfentanil, and propofol were used for induction. Nitrous oxide and sevoflurane were used for maintenance.

Gastroscopy was then performed by using air insufflation. A moderate amount of altered blood was seen throughout the stomach, but there was no obvious food residue. A 5-cm malignant ulcer in the antrum was seen to partially obstruct the pylorus, and there was diffuse oozing of blood from the ulcer rim (Figure 1). The esophagus and duodenum were normal. In an attempt to induce hemostasis, argon plasma coagulation (APC) was applied by using the ERBVIO 200d unit (ERBE Elektromedizin GmbH, Tübingen, Germany). The ERBE settings chosen were routine with 40 watt power and 0.8 L/min flow, and a standard 2.3-mm diameter APC probe was used. Coinciding with the ignition, an instant explosion was felt and heard by all endoscopy staff who were present in theater. This can best be described as analogous to the sound and pulse wave appreciated with a delayed ignition of a gas barbecue or oven. There was immediate collapse of the gastric lumen with loss of vision. With reinsufflation, small bowel loops were seen, and a diagnosis was made of an APC-induced gastric explosion with perforation of the stomach. The patient was transferred to an adjacent operating theater, where he underwent an immediate laparotomy. The stomach was perforated with long lacerations on both the greater and lesser curvatures, extending from the antrum proximal to the cancer to the distal fundus (Figure 2). There was a minor tear of the spleen. At operation, the gastric cancer was noted to have invaded the pancreas, restaging it to a T4 lesion. A palliative subtotal gastrectomy was performed to prevent both ongoing bleeding and impending gastric outlet obstruction. The patient recovered well postoperatively and was discharged home 2 weeks after the incident. The electrosurgical unit was investigated by the manufacturer and found to be normal.

Discussion

This is a case of a gastric explosion induced by APC during gastroscopy. Cases similar to ours are well-described in the setting of colonoscopy and flexible sigmoidoscopy.[1,2] Fermentation by colonic bacteria of fiber and nonabsorbable carbohydrates (including bowel cleansing agents containing mannitol or sorbitol) may produce hydrogen or methane, which are combustible gases.[1,2]

For an explosion to occur, a combustible gas together with a limiting concentration of oxygen (LOC) and an ignition source need to coincide. An explosion can occur over a defined range of concentration for a combustible gas defined by its lower explosion level (LEL) and upper explosion level (UEL). Explosions can occur with hydrogen at concentrations between 4% and 75% with LOC of 4% and with methane at concentrations between

Abbreviations used in this paper: **APC, argon plasma coagulation; LEL, lower explosion level; LOC, limiting concentration of oxygen; UEL, upper explosion level.**

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Figure 1. *Arrow* marks partially obstructed pylorus.

4.4% and 16.3% with LOC of 10.7%.[2] Using an inert gas such as carbon dioxide (CO_2) to inflate the gastrointestinal tract can reduce the amount of oxygen to below the LOC (Supplementary Figure 1).[2] To prevent explosions during colonoscopy or flexible sigmoidoscopy, case studies and American Society for Gastrointestinal Endoscopy guidelines have recommended the use of CO_2 for insufflation.[3–6] To date, no such recommendation has been suggested for gastroscopy because explosions in the stomach have not been reported until now. This has been assumed to be due to the absence of bacteria in the acidic stomach precluding the production of combustible gases.[7]

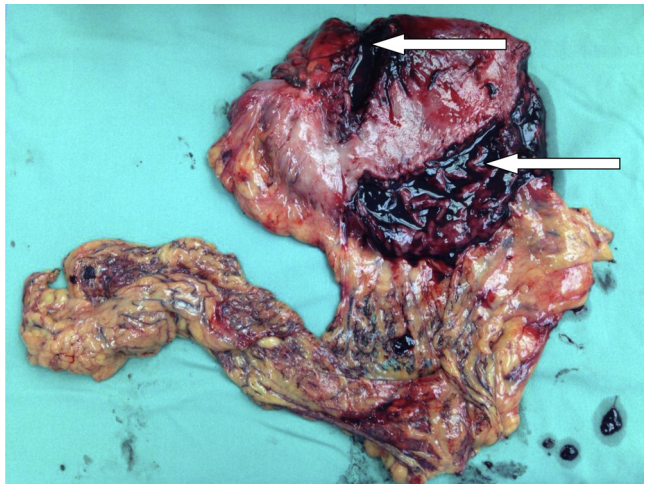

Figure 2. *Arrows* highlight lacerations.

It is possible that anesthetic factors contributed to the potential for a gastric explosion. The patient was preoxygenated and intubated for the procedure, which raises the possibility of unrecognized oxygen insufflation of the stomach. However, the intubation was not prolonged or complicated by accidental esophageal intubation. Sevoflurane, which was used during the initial phase of the general anesthesia, is thought to be inert.[8] Nitrous oxide can increase intestinal gas volumes and may also release oxygen for combustion.[9]

In our case, we assume that the explosion was mainly due to the presence of combustible gases inside the stomach. Partial gastric outlet obstruction caused by the gastric tumor and reduced acidity as a result of proton pump inhibitor therapy may have facilitated bacterial overgrowth. These bacteria may have used blood or food residue as a substrate to produce combustible gases such as methane or hydrogen. Iatrogenic explosions of the stomach during surgical laparotomy by using diathermy cautery have been described in the medical literature in the setting of gastric malignancy, upper gastrointestinal tract obstruction, and in the presence of fermentable substrates such as trichobezoars or significant food residues.[10] These cases and ours clearly demonstrate that combustible gases may be present in the stomach and therefore can cause explosions.

We believe that our case should have great repercussions for future interventional endoscopy in the upper gastrointestinal tract. To prevent this devastating complication, we propose a stepwise process during upper endoscopy with APC to minimize the risk of a gastric explosion. This stepwise process can be easily remembered with the mnemonic APC: A, aspirate; P, preinsufflate; C, coagulate. First, all stomach contents and gases should be aspirated to fully deflate the stomach before contemplating electrosurgical procedures. This is readily achievable in the stomach as opposed to the colon, where partial or segmental deflation is more likely. Deflation should eliminate or reduce the concentration of combustible gases below the LEL. Second, only CO_2 and not air should be used during preinsufflation. This should reduce the concentration of oxygen (LOC) and other combustible gases to safer levels and thereby prevent explosions. Only after the completion of steps A and P should the third step, coagulation, be conducted with minimal risk. Where applicable, these precautions could be applied to all potential interventions involving a heat source in both the upper and lower gastrointestinal tract.

Conclusion

This is a report of an iatrogenic explosion during interventional endoscopy in the upper gastrointestinal tract by using APC. This rare but devastating