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Anesthetic Management of Venous Gas Embolism with Hepatectomy

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Abstract

This is a case review of the intraoperative management of a 46-year-old male patient with a history of stage IV sigmoid colon adenocarcinoma with metastasis to the liver that presented for a robotic assisted sigmoidectomy and partial hepatectomy and had an intraoperative venous gas embolism that resulted in acute hemodynamic instability. Venous gas embolism can be a life-threatening intraoperative event that requires fast recognition of the symptoms and appropriate interventions in response to the patient changes. Evidence suggests that venous gas embolisms are very common with certain procedures but often subclinical. Preventative measures, early recognition, and prompt treatment of venous gas embolisms are important interventions to minimize the risk for any significant hemodynamic instability and any resulting neurological or cardiovascular sequelae.

Anesthetic Management of Venous Gas Embolism with Hepatectomy

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Introduction

- This is a case review of the anesthetic management of a patient that had a suspected venous gas embolism during a robotic assisted hepatectomy.
- The patient required prompt interventions to achieve hemodynamic stability and minimize risks of sequelae.
- Gas embolism (GE) can be a life-threatening intraoperative event that requires fast recognition of symptoms and appropriate interventions in response to patient changes.
- Evidence suggests that venous gas emboli are very common with certain procedures but often subclinical in presentation. [1,3,4,5]

Case Description

- A 46 y/o male patient with a hx of stage IV sigmoid colon adenocarcinoma with metastasis to the liver presented for a robotic assisted sigmoidectomy and partial hepatectomy.

Preanesthetic Evaluation

- Pt had no other significant medical history.
- Physical assessment was unremarkable.
- Preoperative labs were normal.
- Preoperative ERAS medications for multimodal pain management were given.

Intraoperative Management

- Standard GETA induction was uneventful.
- Pneumoperitoneum was achieved with CO_2 and robotic arms were docked without incident.
- During the parenchymal resection portion of the hepatectomy, the patient had a slight decrease in blood pressure, in which phenylephrine was given.
- Several minutes later, this was followed by acute hypotension (systolic in the 40s-50s), drop in $etCO_2$ (to 10s) and desaturation (to low 80s).
- Communicated vital sign changes with surgeon as anesthesiologist came to the bedside.
- Venous gas embolism was suspected.
- 500 mcg phenylephrine was administered with minimal response.
- 3 units of vasopressin were then administered.
- Fluid administration was increased.
- Pt was manually ventilated with 100% FiO_2.
- Robotic arms were undocked to optimize patient position.
- Abdomen was desufflated to reduce CO_2 pressure gradient.
- Pt position made supine with left tilt.
- An additional 5 units of vasopressin were given.
- Hemodynamics improved and a phenylephrine infusion of 0.6 mcg/kg/min was used to maintain hemodynamic stability.
- The case continued and patient remained stable throughout the rest of the procedure.
- Pt was successfully extubated at the end of the procedure.

Postoperative Assessment

- Pt was admitted to ICU postoperatively for monitoring of any neurological or cardiovascular changes.
- Postoperative course was uneventful, and patient was discharged without any neurological or cardiovascular sequalae.

Figure 1: Bubbles filling the RA and RVOT were detected by TEE during hepatic parenchymal resection.[1]

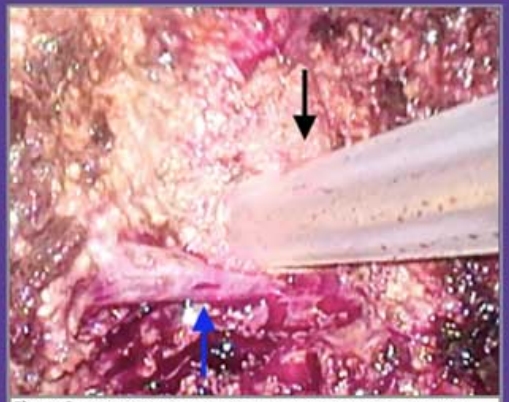

Figure 2: Laparoscopic image of surgical field. A small laceration (blue arrow) without bleeding is detectable in the wall of a vein.[5]

Clinical Presentation of Gas Embolism

- Clinical presentation will vary from asymptomatic to having pulmonary, neurological or cardiovascular changes.[1,4]
- Respiratory changes include a decrease in $etCO_2$ and SpO_2.
- Cardiovascular changes are secondary to reduced cardiac output which rapidly can result in cerebral hypoperfusion.[4]
- Venous gas emboli in small amounts are typically broken up in the capillary bed of the lungs and are absorbed without causing symptoms.[2]
- Monitoring mean arterial pressure is not specific or sensitive for detection of GE, except in the late phase.[1]
- Gas emboli are very common, with one study demonstrating 100% of laparoscopic hepatectomies had some degree of gas entry that was detected with a continuous TEE.[1]
- The most sensitive method of detection is transesophageal echocardiogram (TEE).[1]
- The most convenient method used is monitoring $etCO_2$.[4] However, it is not specific for GE and its reliability during hypotension is difficult to assess.[4]
- Most gas emboli are subclinical and therefore present with minimal to no changes to vital signs.[1]
- Only the most severe gas emboli had any clinical symptoms.[1]

Discussion

- A patient had clinical symptoms of a GE during a robotic assisted hepatectomy, which required prompt interventions to achieve hemodynamic stability.
- Vigilant monitoring and prompt interventions led to the successful intraoperative management of the GE.
- 80% of gas emboli with hepatectomies occurred during resection of the parenchyma of the liver, as was in this case.[1]

Case critique

- This case was well managed after GE was detected with prompt interventions.
- These interventions performed included prompt communication with the surgeon, repositioning of patient, desufflation, ventilation with 100% FiO_2, vasopressor support and fluid administration.
- These interventions were all supported as evidence-based practices for the management of GE.
- Interventions that were not performed that were also reported to be beneficial in managing GE included having additional early detection measures, such as continuous TEEs or precordial stethoscope.
- Having existing central line that was available would also have been beneficial to possibly aspirate any GE. This was not performed on this patient.

Practice Recommendations for the Management of Gas Embolism

Prevention

- Prevention strategies include reducing head up position, adequate hydration to increase central venous pressure, and avoidance of nitrous oxide which can expand gas emboli.[4]
- Carbon dioxide (CO_2) is generally used for pneumoperitoneum for laparoscopic procedures.[3]
- Avoid high pressure pneumoperitoneum (>12 mmHg) which exceed the low central venous pressure (<5 mmHg) that predisposes the patient to CO_2 embolism.

Early Detection

- Early detection is best accomplished from the vigilance of the anesthesia provider.
- Awareness of surgeries that have a higher risk of gas emboli are important.
- Most sensitive detection method is transesophageal echocardiogram, but due to the invasive nature, a more practical method is $etCO_2$ monitoring or using a precordial stethoscope to monitor for a "mill-wheel" murmur.[2,4]

Treatment

- 3 goals of treatment are to limit gas entrainment, reduce entrained gas emboli, and provide hemodynamic support.
- ***Limit further gas entrainment:***
  - Communicate changes to surgeon to possibly cauterize any areas of bleeding that may entrain gas.
  - Reposition patient to supine and left tilt to reduce gas movement to lungs.
  - Desufflate pneumoperitoneum to reduce CO_2 pressure gradient.
- ***Reduce entrained gas:***
  - Aspirate entrained gas from right atrium through an existing central line.
- ***Hemodynamic support:***
  - Ventilate with 100% FiO_2 to improve ventilation mismatch and hypoxia.
  - Inotropic support to promote cardiac output.[4]
  - Fluid administration to promote adequate preload and increase central venous pressure.[4]

Conclusion

- Venous gas emboli are very common with laparoscopic hepatectomies and anesthesia providers should remain aware of the high risk of GE.
- Most gas emboli are often subclinical in presentation but there is the risk of leading to significant hemodynamic instability as well as neurological and cardiovascular sequalae.
- For early detection of GE, consider using a precordial stethoscope to auscultate for a "mill-wheel" murmur or TEEs to visualize GE.
- Anesthesia providers should remain vigilant on the surgical risks, preventative measures, early detection, and prompt treatment of gas emboli.

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