

Oxygen embolism caused by accidental subcutaneous injection of hydrogen peroxide during orthopedic surgery

A case report

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Abstract

Introduction: We report a 39-year-old male patient with a fracture of the right acetabulum undergoing open reduction and internal fixation with a plate under general anesthesia. At closure, the surgeons injected 0.75% ropivacaine into the subcutaneous tissue of the incision wound for postoperative analgesia. Soon after injection, subcutaneous emphysema at the injection site and a sudden decrease in end-tidal CO₂ tension with crude oscillatory ripples during the alveolar plateau phase were observed. Shortly thereafter, it was found that the surgeons had mistakenly injected hydrogen peroxide instead of ropivacaine. Fortunately, the patient recovered to normal status after 10 minutes. After the surgery, the patient was carefully observed for suspected pulmonary embolism and discharged without complications.

Conclusion: Adverse events related to medication errors can occur in operating rooms, and most cases can be prevented through communication and verification by medical staff. The use of hydrogen peroxide should be reevaluated; when used, medical staff should be aware of the risk of oxygen embolism and take extreme care.

Abbreviations: ABGA = arterial blood gas analysis, ECG = electrocardiogram, HR = heart rate, P_{ET}CO₂ = end-tidal CO₂ tension, POD = postoperative day.

Keywords: hydrogen peroxide, medication error, oxygen embolism

1. Introduction

Intraoperative medications may pose a greater threat to patient safety compared to other in-hospital medications. Unlike the general ward, operating rooms are a highly stressful and time-sensitive environment where medications are often injected without the standard safety checks. Hence, incorrect doses, concentrations, or even medications are sometimes injected, which can have fatal consequences.^[1] Hydrogen peroxide is commonly used as an antiseptic, hemostatic agent, and irrigant for superficial wounds; however, there have been many case reports of intraoperative oxygen embolism leading to severe morbidity and mortality.^[2–4] Here, we report a case in which hydrogen peroxide was mistakenly subcutaneously injected in

place of ropivacaine for postoperative analgesia during an orthopedic surgery, without a standard safety check. The clinical symptoms of the case are discussed along with a review of the relevant literature.

2. Case report

The report was approved by Institutional Review Board of Soonchunhyang University Cheonan Hospital (SCHCA 2017-07-018), and written informed consent was provided by the patient. A 39-year-old male patient (height: 165 cm, weight: 57 kg) with a fracture of the right acetabulum from a traffic accident was scheduled to undergo open reduction and internal fixation with a plate under general anesthesia. He had no notable medical history, and blood tests at the emergency room indicated hemoglobin 8.7 g/dL, hematocrit 25.4%, aspartate aminotransferase 108 U/L, and alanine aminotransferase 50 U/L. He was given 6 units of packed red blood cells and 3 units of fresh frozen plasma, after which increases in hemoglobin (10.1 g/dL) and hematocrit (29.4%) were observed. Electrocardiogram (ECG) and a chest radiograph showed no abnormal findings.

After premedication with glycopyrrolate (0.2 mg, intramuscular injection, 30 minutes before anesthesia), the patient's ECG, noninvasive blood pressure, and pulse oxygen saturation were monitored. The ECG was normal, with a blood pressure of 126/82 mmHg, heart rate (HR) of 89 beats/min, and oxygen saturation of 99%. Anesthesia was induced with 40 mg 1% lidocaine and 120 mg propofol, with 50 mg rocuronium intravenously infused after confirming loss of consciousness. Intubation was performed 2 minutes later. Anesthesia was maintained with 6 vol% desflurane and a 0.5 fraction of inspired oxygen. The patient was ventilated at 12 breaths/min with a tidal volume of 450 mL.

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Surgery proceeded with the patient in the left decubitus position, with a blood pressure of 100–110/50–65 mmHg, HR of 70 to 80 beats/min, end-tidal CO₂ tension (P_{ET}CO₂) of 35 to 37 mmHg, and oxygen saturation of 99% to 100% maintained during the surgery. Approximately 2 hours into the surgery, the operating surgeon closed the subcutaneous tissues at the incision site and subcutaneously injected what was thought to be 50 mL 0.75% ropivacaine, which had been prepared beforehand, for postoperative analgesia. After the injection, a subcutaneous emphysema was palpated at the injection site, at which time the surgeon realized that the injected medication was 3% hydrogen peroxide rather than the intended ropivacaine. Capnography revealed crude oscillatory ripples during the alveolar plateau phase, and P_{ET}CO₂ declined to 22 mmHg. The patient's vital signs were: blood pressure 120–130/70–80 mmHg, HR 110 to 125 beats/min, and pulse oxygen saturation 100%. Arterial blood gas analysis (ABGA) indicated pH 7.343, PaCO₂ 49.5 mmHg, PaO₂ 164.5 mmHg, HCO₃⁻ 26.3 mmol/L, and O₂ saturation 99.0%. About 10 minutes later, the patient recovered to a blood pressure of 95–105/55–70 mmHg, HR of 80 to 90 beats/min, and P_{ET}CO₂ of 37 to 38 mmHg with normal capnography findings without changing the ventilator conditions. Up to this point, blood loss was 400 mL and urinary output was 150 mL, with 800 mL crystalloid fluid and 500 mL colloid fluid injected intravenously. After the vital signs had stabilized, the skin was sutured and the position of the patient was changed to the supine position. To reverse the muscle blockage, 15 mg pyridostigmine and 0.4 mg glycopyrrolate were intravenously injected. The patient was extubated after spontaneous breathing recovery and transferred to the intensive care unit.

Until postoperative day (POD) 2, subcutaneous emphysema was palpated at the surgical site (Fig. 1). On POD 1, ABGA readings were: pH 7.452, PaCO₂ 42.6 mmHg, PaO₂ 68.0 mmHg, HCO₃⁻ 29.1 mmol/L, and O₂ saturation 94.2%. On POD 5, the readings were: pH 7.418, PaCO₂ 43.9 mmHg, PaO₂ 88.0 mmHg, HCO₃⁻ 27.7 mmol/L, and O₂ saturation 96.8%. The patient was discharged on POD 15 without complications.

3. Discussion

Human error causes harm and has serious consequences for patients, even death. In the United States, approximately 100,000

to 400,000 patients die as a result of human error every year.^[5] Most medication errors are preventable events that pose a particularly serious threat when they occur in operating rooms. According to one report, 5.3% of all medication errors occur in the operating room, 79.3% of which could have been prevented.^[1] In our case, the circulating nurse prepared hydrogen peroxide, which was used to irrigate the suture site after suture. However, that nurse did not tell to the scrub nurse, who believed that ropivacaine was used for postoperative analgesia without confirmation. The adverse drug event could have been prevented if the drug had been checked between the surgeon and nurses prior to injection.

Hydrogen peroxide rapidly decomposes into water and oxygen when it comes in contact with an organic tissue with abundant catalases. It is commonly used as an antiseptic, a hemostatic agent, and an irrigant for superficial wounds. Although it is still widely used, the use of hydrogen peroxide is controversial, Reid et al^[6] asserted that its use must be reconsidered due to a lack of evidence to support its suitability. Furthermore, there have been many cases in which intraoperative oxygen embolism has led to severe morbidity and mortality.^[2–4]

Oxygen embolism caused by hydrogen peroxide is thought to be caused by the entry of hydrogen peroxide into open vessels. However, Mut et al^[7] reported that hydrogen peroxide can permeate through brain tissue and reach deeper blood vessels, where it reacts with catalase present in endothelial walls. It has also been suggested that hydrogen peroxide directly increases endothelial permeability and passes through cell walls through aquaporins.^[8] These mechanisms explain how hydrogen peroxide causes numerous emboli in intact tissues^[9]; when hydrogen peroxide is used near vessels or major organs, such as the brain, heart, and lungs, even a trace amount (~5 mL) can lead to oxygen embolism.^[10]

A sudden drop in P_{ET}CO₂, with or without hypotension, is grounded for diagnosing acute pulmonary embolism during standard anesthetic monitoring in an operating room.^[11] In our case, P_{ET}CO₂ suddenly dropped from 35–37 to 22 mmHg without hypotension, and ABGA performed at the time revealed that PaCO₂ (49.5 mmHg) differed from P_{ET}CO₂ by more than 3 mmHg. This occurs when the anatomic dead space increases, such as through an open ventilator circuit and shallow breathing, and physiologic dead space increases, such as through obstructive



Figure 1. Pelvis anterior posterior radiograph (A) at postoperative 2 hours showing subcutaneous emphysema (arrows) at the surgical site, (B) at postoperative 6 days.

lung disease, excessive lung inflation, low cardiac output, and pulmonary embolism.^[12] In addition, a sudden drop of $P_{ET}CO_2$ leads to crude oscillatory ripples during the alveolar plateau phase on the capnography. One report suggested that such a capnographic waveform is not generally present in subclinical pulmonary embolism, although it can occur.^[13] Our patient had symptoms of mild pulmonary embolism. We speculate that the symptoms were mild because we proceeded with the surgery while ensuring hemostasis of vessels at the surgical site, and because the thigh is distant from any major organs.

For the accurate diagnosis of pulmonary embolism, lung scanning, computed tomography pulmonary angiography, and echocardiography are required. In our case, the patient recovered to normal status after 10 minutes and was stable in the intensive care unit. Thus, we did not perform these procedures, although they would have strengthened this report.

In conclusion, adverse events related to medication errors can occur in operating rooms, and most cases can be prevented through communication and verification by medical staff. The use of hydrogen peroxide should be reevaluated; when used, medical staff should be aware of the risk of oxygen embolism and take extreme care.

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